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ON THE PREDICTION AND APPLICATION OF LOW ENERGY X-RAY INTERACTI--ETC(U)
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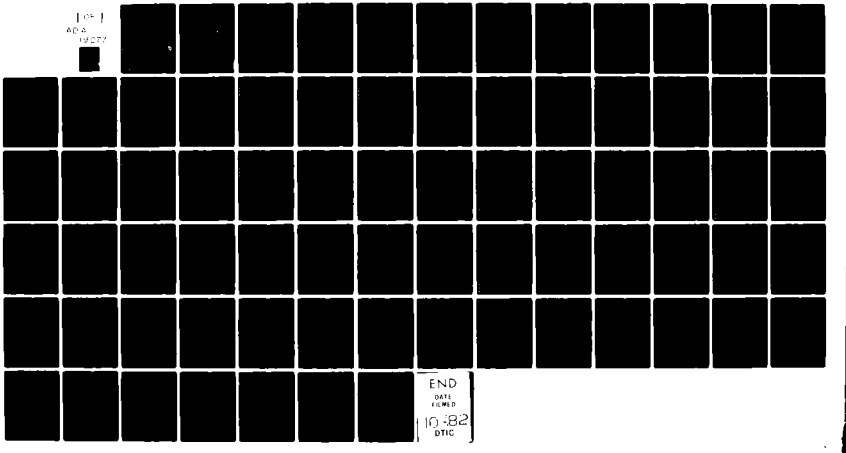

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ON THE PREDICTION AND APPLICATION OF LOW ENERGY X-RAY INTERACTIONS

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Presented here with the f_1/f_2 tables are reviews on the development and application of the atomic scattering factors for the basic descriptions of the interactions which are important in the design and application of spectroscopic measurements in the low-energy x-ray region. These are somewhat expanded and updated versions of works that have appeared originally in the AIP Conference Proceedings No. 75 on Low Energy X-Ray Diagnostics (APS Topical Conference, Monterey, 1981) and entitled:

1. "Low Energy X-Ray Interactions: Photoionization, Scattering, Specular and Bragg Reflection," B. L. Henke.
2. "Low Energy X-Ray Spectroscopy with Crystals and Multilayers," B. L. Henke.
3. "Appendix: The Atomic Scattering Factor, $f_1 + if_2$, for 94 Elements and for the 100 to 2000 eV Photon Energy Region," B. L. Henke, P. Lee, T. J. Tanaka, R. L. Shimabukuro and B. K. Fujikawa.

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[1] "Low Energy X-Ray Interaction Coefficients: Photoabsorption, Scattering and Reflection," Atomic Data and Nuclear Data Tables 27 (1982).

LOW ENERGY X-RAY PHYSICS PROGRAM

January 1982

Department of Physics and Astronomy
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Honolulu, Hawaii 96822

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Low Energy X-Ray Interactions: Photoionization, Scattering, Specular and Bragg Reflection

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ABSTRACT

For the low energy x-ray region of 100-2000 eV, the complete atomic interaction, coherent scattering and photoelectric absorption can be described by a complex scattering amplitude which may be given through the atomic scattering factor, $f_1 + if_2$. For this low photon energy region, it is shown by the relativistic quantum dispersion theory that the atomic scattering factors can be uniquely determined from simple relations involving only the atomic photoionization cross section dependence upon photon energy. We have compiled "state of the art" tables for the photoionization cross sections for 94 elements and for the photon energy region of 30- 10,000 eV. With this compilation, we have established atomic scattering factor tables for the 100-2000 eV region. By a summing of the complex, atomic scattering amplitudes, a low energy x-ray interaction can be determined. Even for atoms in the molecular or solid state the scattering cross sections remain atomic-like except for photon energies very near the thresholds. Using practical examples, the methods of calculation, with the atomic scattering factors, are reviewed here for the following: 1) x-ray energy deposition within materials (energy response of x-ray photocathodes); 2) transmission through a homogeneous medium: refraction; 3) transmission through a random collection of uniform spheres: low angle scattering in an inhomogeneous medium; 4) specular, Fresnel reflection (total and large angle reflection) at smooth boundary; and 5) Bragg reflection from a periodic, layered system--(reflection by crystals and multilayers).

I. INTRODUCTION--THE ATOMIC SCATTERING FACTORS

In this review, we would like to discuss, for the low energy x-ray region (100-2000 eV region), how the interactions of absorption, scattering and reflection can be well described by using the atomic scattering factors as the primary parameters for the material system. In the Appendix of these proceedings we present tables for the atomic scattering factors as directly derived from a recent work [1] on a "state of the art" compilation of the photoionization cross sections for 94 elements for the 30-10,000 eV region, along with the calculated atomic scattering factors for the 100-2000 eV photon energy region. We present here, as applied to selected examples of relevance in low energy x-ray diagnostics, some basic procedures for predicting low energy x-ray interactions.

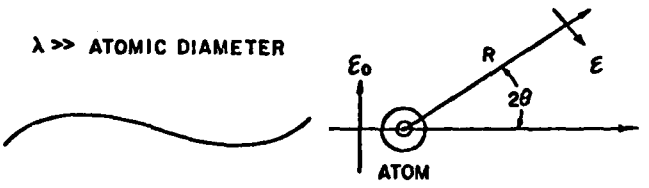
The interaction physics for the conventional x-ray region (for photon energies above 1000 eV) has been presented by many excellent texts including that of Compton and Allison [2] and R. W. James [3]. What is summarized here is an extension and specialization of this physics that is useful for the long wavelength x-ray region of 10-100 A.

For the low energy x-rays, the interaction can be defined as simply coherent scattering and photoelectric absorption. Incoherent scattering is negligible. The complete interaction with an atom may thus be described by a complex scattered amplitude defined by an atomic scattering factor, $f_1 + if_2$, as depicted in Figs. 1 & 2. The scattered amplitude is given by this factor multiplied by that amplitude which would be scattered if the atom were replaced by a free, Thomsonian electron. Here, r_0 is the classical electron radius, m the electron mass, c the velocity of light and R the distance from the atom to the point of measurement. Because the wavelengths of interest are large as compared with the dimensions of the electron distributions within the atom, we make the important assumption here that essentially all electrons will scatter effectively in phase for all but the largest angles of scattering so that the atomic scattering factor components, f_1 and f_2, may be considered angle independent. The complex amplitude of atomic scattering therefore will be dependent only upon the angle of scattering, 2θ, through the polarization factor, P(2θ), of the Thomsonian term. P(2θ) is equal to unity or cos 2θ depending upon whether the incident electric vector is perpendicular to or parallel to the plane of scattering. As will be discussed below, the relative roles of the coherent scattering and the photoelectric absorption will be expressed through f_1 and f_2, respectively.

The relativistic quantum dispersion theory for atomic scattering and the calculation of the atomic scattering factors has been presented by Cromer and Lieberman [4] and by Jensen [5] (along with their references). In Fig. 2 are shown their results including the relativistic corrections, Δf_r, to the semiclassical, usual relations for f_1 and f_2. Here Z is the atomic number, h Planck's constant, mc^2 rest mass energy of the electron, E_{tot} the total energy of the atom and E the photon energy. Cromer and Lieberman have estimated E_{tot} (a negative quantity) for all the elements and from their table we have fit the following polynomial for the larger term in Δf_r.

$$\frac{5}{3}\frac{|E_{tot}|}{mc^2} = 2.19 \times 10^{-6}Z^3 + 1.03 \times 10^{-4}Z^2 .$$

LOW ENERGY X-RAY SCATTERING



SINGLE ELECTRON SCATTERING AMPLITUDE × ATOMIC SCATTERING FACTOR

$$\mathcal{E}(\theta,\lambda) = -\left[\mathcal{E}_0\left(\frac{r_0}{R}\right)P(2\theta)\right](f_1(\lambda)+if_2(\lambda))$$

Figure 1

THE ATOMIC SCATTERING FACTOR, $f_1 + if_2$

RELATIVISTIC QUANTUM DISPERSION RELATIONS:

$$f_2(E) = \frac{E\mu_a(E)}{(2\ r_0 hc)}$$

$\mu_a(E)$--ATOMIC PHOTOIONIZATION CROSS SECTION

AND

$$f_1(E) = Z + \frac{1}{(\pi r_0 hc)} \int_0^\infty \frac{\epsilon^2 \mu_a(\epsilon) d\epsilon}{E^2 - \epsilon^2} - \Delta f_r,$$

WHERE $\Delta f_r = \frac{5}{3}\frac{|E_{tot}|}{mc^2} + \frac{Z}{2}\left(\frac{E}{mc^2}\right)^2$

WHICH IS NEGLIGIBLE FOR THE LOW ENERGY X-RAY REGION.

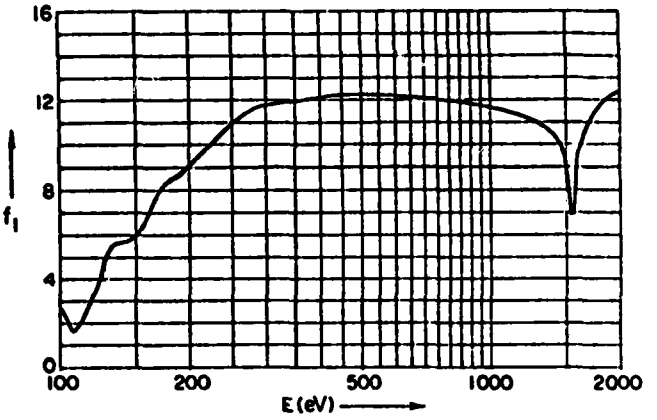
Figure 2

For the low energy x-ray region it is immediately evident that this and the second relativistic term in Δf_r are completely negligible except near thresholds where f_1 becomes small as compared with Z. An important argument here, therefore, is that for the low energy x-ray region, the atomic scattering factor, $f_1 + if_2$, can be uniquely determined through these relations in terms of the total atomic photoionization cross section and its dependence upon photon energy. It may be noted that f_2 is directly proportional to the atomic photoionization cross section for a given photon energy, E. It will exhibit the same structures near thresholds as does the photoionization cross section, $\mu(E)$. The relation for f_1 suggests that the important anomalous scattering contribution (through the integral term) depends upon a knowledge of the photoionization cross section dependence upon photon energy from a very small to very large value of photon energy. The nature of this integral, however, is that its value is sensitive to an integration range of energies relatively close to E. In our calculations [1] for f_1, we have found it convenient to use a range from 30 eV to 85 keV with our greatest concern for knowing precisely the cross sections in the intermediate region of 100-2000 eV.

In Figs. 3, 4 and 5 we present examples of plots of the calculated scattering factor components, f_1 and f_2, for aluminum, copper and xenon. In the f_2 plots for the photon energy region below about 300 eV we have indicated values corresponding to representative, available experimental data including that which we have adoped for this fitting. [6-10] It is important to note that throughout the low energy x-ray region, the f_1 values are appreciably different from the classical Thomsonian value of Z (as a result of electronic binding and consequent anomalous scattering). It is proposed here that with sufficient accuracy we may assume that the low-energy x-ray photoionization cross sections and, correspondingly, the atomic scattering factors are atomic-like even in the chemical and solid states. This effect is illustrated in Fig. 6 where shown is a comparison of the photoionization cross sections as measured in the vapor and in the solid state for the elements sodium, iron and barium. [11-13] Near thresholds there are characteristically large departures from the atomic-like character when the atoms are in the molecular and solid state. At the absorption edge may be sharp excitonic structures [14] and nearby may be the extended absorption fine structure (exafs) [15]. Nevertheless, as has been discussed by many authors, [16-18] above about 50 eV and away from thresholds, the photoionization cross sections are relatively independent of the state of the atomic system. In our integrations for f_1 we have used values for $\mu(E)$ that have been averaged through such structures near the thresholds.

Thus for the low energy x-ray region of interest here (100-2000 eV) we define and have tabulated the

ATOMIC SCATTERING FACTOR, $f_1 + if_2$--ALUMINUM



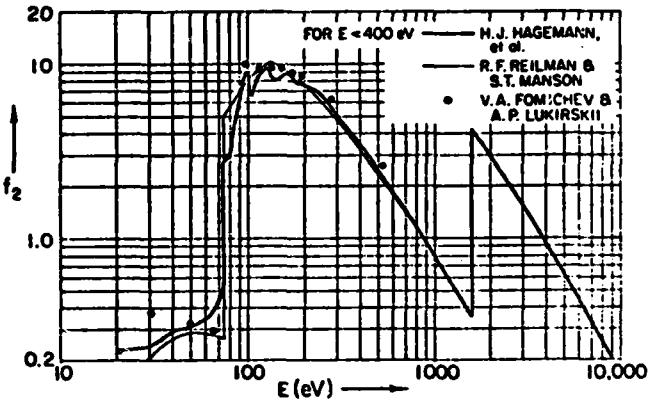
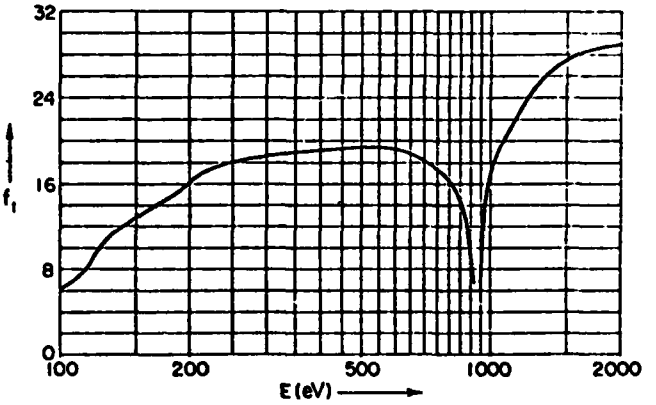


Figure 3

ATOMIC SCATTERING FACTOR, $f_1 + if_2$--COPPER



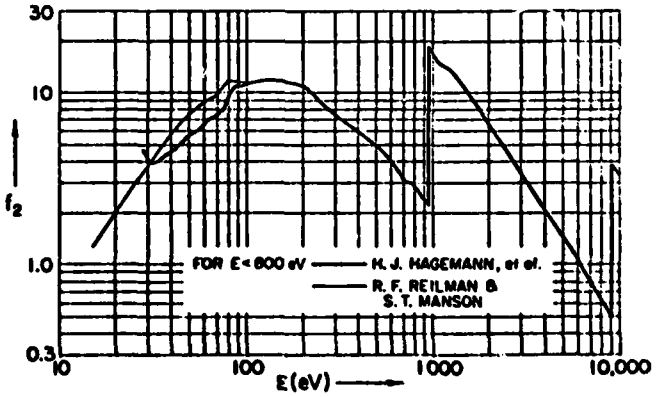


Figure 4

ATOMIC SCATTERING FACTOR, $f_1 + if_2$--XENON

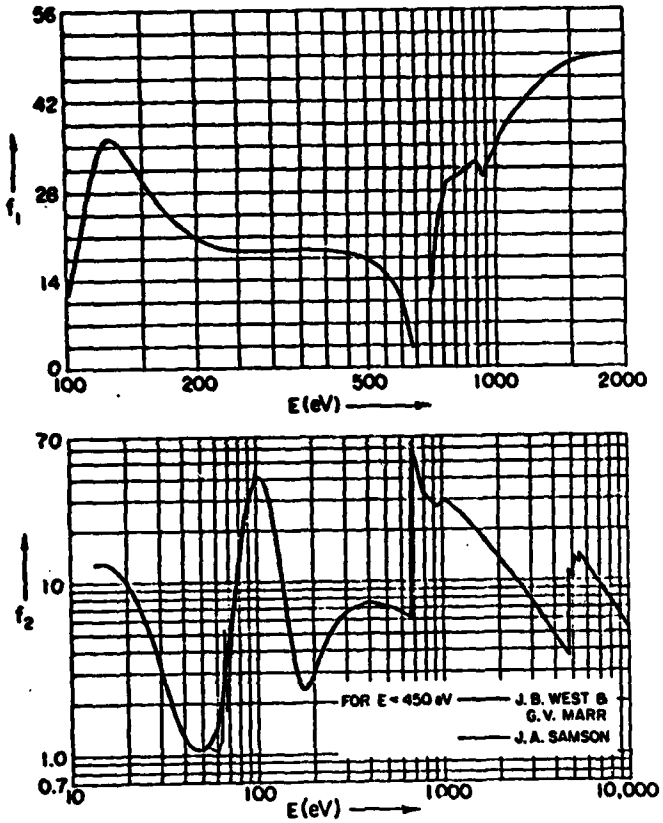


Figure 5

atomic scattering factors (a) as uniquely defined by the best available photoionization cross section data; (b) as being essentially independent of scattering angle; and (c) as being effectively independent of the state of the atomic system--except for photon energies near thresholds.

For the scattering of the shorter wavelengths at the larger angles, the variation in phase of the scattered amplitudes originating from different points within the atomic electron spatial distribution will introduce an angle-dependent reduction of the atomic scattering factor. A very simple and usually sufficiently accurate modification of the atomic scattering factor as defined in Fig. 2 which can account for this effect of charge distribution is to replace the atomic number, Z, in f_1, by the angle-dependent form factor, f_0, for the given atom [2]. This procedure is discussed in Appendix I.

II. LOW ENERGY X-RAY INTERACTION DESCRIPTION

Generally one may treat such problems as the transmission of radiation, particle scattering, specular and Bragg reflection with a macroscopic description as an electromagnetic wave boundary value problem using material constants such as the dielectric constant, K, and the refractive index, n_r, or equivalently, by an atomic approach by summing the atomic scattered amplitudes from the irradiated atomic system and using the atomic scattering factors. By comparing the solutions of such interaction problems by these approaches, the following relationships between the complex dielectric constant, K, the refractive index, n_r, and the atomic scattering factors for the x-ray region are directly established.

For the low energy x-ray region, we define the complex dielectric constant, K, as

$$K = 1 - \alpha - i\gamma \qquad (1)$$

and the complex refractive index, n_r, by

$$n_r = 1 - \delta - i\beta \,, \qquad (2)$$

where characteristically these unit decrements, α, γ, δ and β, are small as compared with unity. We then find that the following relationships between the atomic and the macroscopic parameters obtain:

$$\delta = \frac{r_0\lambda^2}{2\pi} n\bar{f}_1 = \frac{\alpha}{2} \qquad (3)$$

$$\beta = \frac{r_0\lambda^2}{2\pi} n\bar{f}_2 = \frac{\gamma}{2} \,, \qquad (4)$$

where the average atomic scattering factor per unit volume, $n\bar{f}$, is given by

$$n\bar{f}_1 = \sum_q n_q f_{1q} \qquad (5)$$

$$n\bar{f}_2 = \sum_q n_q f_{2q} \,. \qquad (6)$$

Here n_q is the number of atoms per unit volume of type-q.

Usually the E & M boundary value solutions can be more formal, rigorous and, however, more tedious and less intuitive. Often a description by summing over atomic scattered amplitudes, which is phenomenological, is also more flexible and amenable to practical approximation.

PHOTOIONIZATION CROSS SECTIONS ATOMIC VS SOLID STATE

VAPOR ——

METAL ·····

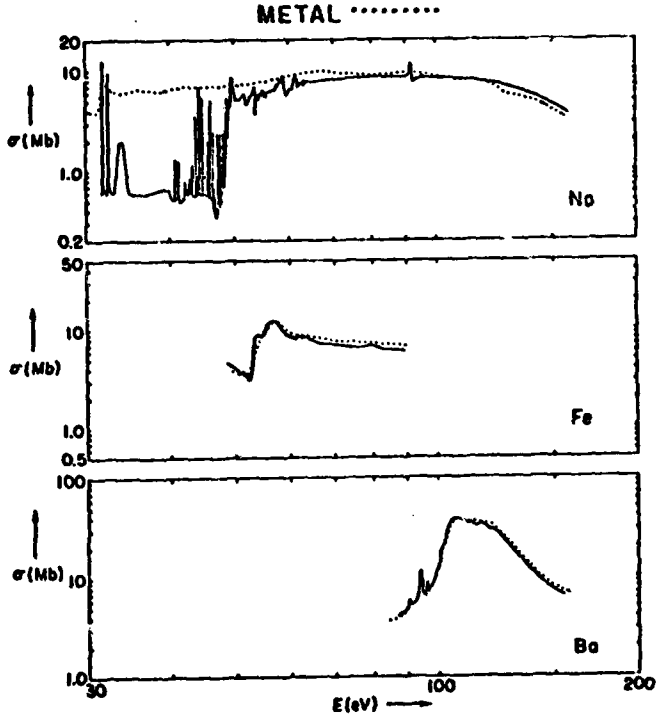


Figure 6

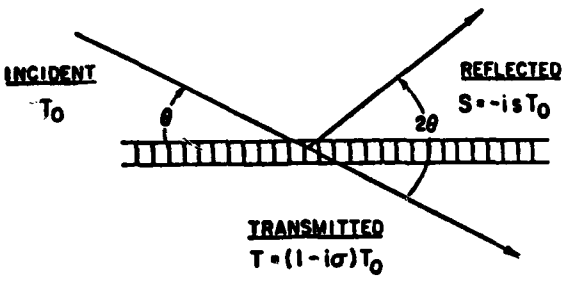


Figure 7

In transmission scattering, specular and Bragg reflection description, a first step in summing the atomic scattered amplitudes over a given irradiated system of atoms is illustrated in Fig. 7. Here the amplitude that is transmitted and specularly reflected by an elementary atomic plane is described. The absorptive factor, σ, in the transmitted direction, and the reflective factor, s, for the coherent constant phase scattering geometry as allowed only in the specular direction, 2θ, may be related to the atomic scattering factor, $f_1 + if_2$, by simply integrating over equiphase Fresnel zones throughout the plane [3].

If, as in many practical systems, the atomic layers are within periodic systems of layers as in planar crystals or in multilayers, with a periodicity length normal to the surface equal to d, σ and s may be simply generalized for this layer system of thickness, d, in terms of the average scattering factor per unit volume, $n\bar{f}$, defined in Eq. (5), and a structure factor per unit volume, $\phi F_1 + i\phi F_2$.

Upon summing over the scattered amplitudes within this layer system a composite scattering factor per unit volume for scattering in a direction 2θ is defined as the unit cell structure factor per unit volume as follows:

$$\phi F = \frac{1}{Ad} \sum_p x_p (f_{1p} + if_{2p}) e^{-(\frac{4\pi \sin\theta}{\lambda}) z_p} , \qquad (7)$$

where the volume of the unit cell is Ad and within the unit cell at a position z_p from a reference plane there are x_p atoms of type-p.

As is often possible, if z_p may be measured from a central symmetry plane, the ϕF_1 and ϕF_2 components may then be written simply as

$$\phi F_1 = \frac{1}{Ad} \sum_p x_p f_{1p} \cos(\frac{4\pi \sin\theta}{\lambda} z_p) \qquad (8)$$

$$\phi F_2 = \frac{1}{Ad} \sum_p x_p f_{2p} \cos(\frac{4\pi \sin\theta}{\lambda} z_p) . \qquad (9)$$

The next step in an interaction description is to sum the wave amplitudes from a given system of planes of atoms (or of unit cells) and for a given angle of scattering, 2θ. As the initial wave, as depicted in Fig. 7, proceeds to the next layer it will be partially reflected again to contribute to the total reflected wave system and this partially reflected wave will also partially reflect back as a component to be added to the initial transmitted wave system, etc. In this way the total transmitted and reflected wave systems may contain the contributions of many such multiply reflected components. The works of Darwin and Prins were perhaps the first that present a relatively simple solution for the total reflected and transmitted wave systems. [2,3, 19,20] Their approach was to write the self-consistent, difference equations for the transmitted amplitude, T_N, and total reflected amplitude, S_N, for successive layers (indexed by N) taking into account the phase shift, $kd \sin\theta$, of the waves between layers. We refer the interested reader to the relatively simple and straightforward solution of these difference equations for the reflected wave as a function only of d, θ, σ and s. Recently Smirnov[21] has written the difference equations as differential equations for a continuous set of close-spaced planes in order to treat, in particular, the reflection of x-rays from an amorphous medium interface. Smirnov's solution for a perfectly smooth interface immediately reduces to the familiar Fresnel equations as written for x-ray reflection by simply replacing the f_1 and f_2 parameters by their optical constant equivalents through relations (3) and (4).

This inclusion of the effects of multiple reflection and absorption is called a dynamical approach. In certain problems a simple and useful approximation for the summing for the total reflected wave system from a system of planes can be obtained by neglecting the effect of the multiple reflection and the absorption reduction of the incident wave. For example, this can be appropriate for scattering by small crystals or particle systems for which relatively few planes are involved. This simplification in the summing of the reflected waves is called a kinematical approach.

In the sections that follow, we would like to summarize the results of such calculations for some examples of practical interest.

A. NORMAL INCIDENCE TRANSMISSION OF LOW ENERGY X-RAYS

Using the Darwin-Prins-Smirnov(DPS) approach, we have calculated the total transmitted and reflected amplitude for a normally incident, unpolarized plane wave of x-rays for uniform, amorphous solid. Taking the square of the moduli of these amplitudes, we find that the reflected intensity is negligibly small, as expected, and that the transmitted intensity is reduced exponentially with distance z from the surface as $\exp(-2r_e\lambda n\bar{f}_2)$, where nf_2 is the average scattering factor component, f_2, per unit volume as given by Eq. (5). From an E & M, boundary value solution for the Poynting vector describing this transmitted energy flow, we find [17] that it is reduced with z by the factor $\exp(-4\pi\beta/\lambda)z)$. Comparing these exponential factors with that defined in terms of the linear absorption coefficient, μ_l, we obtain the relations

$$\mu_l = \frac{4\pi\beta}{\lambda} = 2r_e\lambda n\bar{f}_2 \qquad (10)$$

which is consistent with relation (4). This result may also be written as

$$\bar{f}_2 = \frac{E\mu_a(E)}{2\, r_e hc} , \qquad (11)$$

where μ_a is an atomic (or molecular) photoionization cross section equal to μ_l/n. This result also follows from the quantum theory of dispersion as noted in Fig. 2.

B. THE QUANTUM YIELD FOR LOW ENERGY X-RAY PHOTOCATHODES

In a recent work [23] we have shown experimentally and by a simple phenomenological model that the number of electrons that are photoemitted per normally incident photon, the quantum yield, Y, is dependent upon photon energy through the factor, $pE\mu(E)$ or $E\mu_l(E)$. E is the

photon energy, ρ, the mass density of the photocathode, μ and μ_ℓ are the mass and linear photoionization cross sections, respectively. We may thus write for the photocathode efficiency

$$Y \sim n\bar{f}_2 \qquad (12)$$

by applying Eq. (11) where $n\bar{f}_2$ is the average scattering factor, f_2, per unit volume for the photocathode and given in Eq. (5). Thus the f_2 parameters which have tabulated here and in Ref. 1 can be used directly to estimate the photon energy dependence of x-ray photocathodes.

C. SMALL ANGLE SCATTERING OF LOW ENERGY X-RAYS

As has been noted in Sec. II-A, a measurement of the attenuation of the transmitted intensity through a uniform, homogeneous material can be used to determine the photoionization cross section, μ, and the atomic scattering factor component, f_2. If the sample material consists of small particles or voids of dimensions large compared with the wavelength of the incident radiation, the direct beam will be reduced further by the resulting coherent scattering. In order to estimate this effect and/or to evaluate material scattering generally, a description of the scattering by spherical particles or voids is presented here as a relevant example.

This problem has been discussed in some detail in a previous work by the author [24]. By neglecting absorption within the sphere (each differential plane receiving essentially the same incident intensity) and neglecting multiple interference, we may calculate, relatively easily, the scattered intensity distribution by a kinematical approach. Integrating the differential amplitudes which are proportional to the circular section area of $\pi(R^2 - z^2)$ (see Fig. 8) and with phase angle relative to that for the central plane, $4\pi z \sin\theta/\lambda$, (with 2θ the angle of scattering) we obtain the total amplitude of the scattered wave [24]. Taking the modulus squared, we then obtain the intensity distribution at a distance, r, from a spherical particle.

$$I = I_e\left(\frac{4\pi^2 r_e^2 R^6}{r^2}\right)\left((nf_1)^2 + (nf_2)^2\right)(1 + \cos^2 2\theta)\left(\frac{J_{3/2}(u)}{u^3}\right). \qquad (13)$$

Here again $n\bar{f}_1$ and $n\bar{f}_2$ are the averaged scattering factor components per unit volume, from Eq. (5); $u = \frac{4\,R\sin\theta}{\lambda}$, and $J_{3/2}(u)$ is the Bessel function of order 3/2. For small angle scattering, i.e., for $\lambda \ll R$, the central maximum is well approximated by a Gaussian distribution

$$I = \frac{8\pi^2}{9}\frac{R^6 r_e^2}{r^2}\left((n\bar{f}_1)^2 + (n\bar{f}_2)^2\right)(1 + \cos^2 2\theta) I_e e^{-\frac{u^2}{5}} \qquad (14)$$

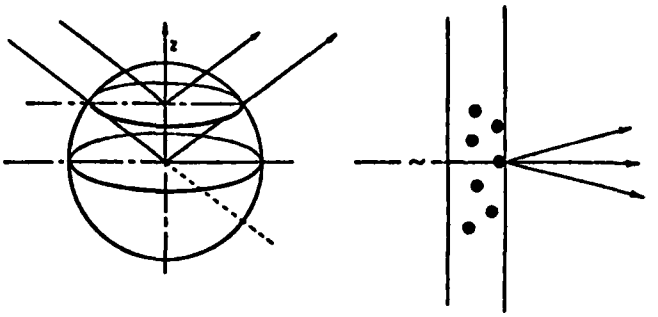
of angular width, $\Delta\theta = \sqrt{5/8\pi^2}\,(\lambda/R)$.

The E & M boundary value solution was rigorously obtained in series form using Legendre polynomials by Mie [25]. This solution was expressed in closed form by Hart and Montroll [26] and by van de Hulst [27] for "soft" spheres for which absorption was not completely neglected. We have taken this dynamical model result which may be appropriate for the lower energy x-ray region and have shown that it reduces to Eq. (13) in the low absorption limit by again replacing the optical constants, δ and β, by the equivalent functions in f_1 and f_2 given in Eqs. (3) and (4). [24] By integrating over a sphere to obtain the total scattering through all angles we have obtained expressions for the total cross sections. The total cross section per particle, s_p, and the total cross section per gram, s_m, as derived from Eq. (13), become

$$s_p = r_e^2\lambda^2 R^4\left((n\bar{f}_1)^2 + (n\bar{f}_2)^2\right)$$

$$s_m = \frac{3}{4\pi}\frac{R r_e^2 \lambda^2}{\rho_e}\left((n\bar{f}_1)^2 + (n\bar{f}_2)^2\right) \qquad (15)$$

LOW ENERGY X-RAY PARTICLE SCATTERING



LOW ANGLE SCATTERING CROSS SECTION/PARTICLE

$$S_p = \phi^2 R^4 r_o^2 \lambda^2 (f_1^2 + f_2^2)$$

(ϕ = ATOMS/UNIT VOLUME)

Figure 8

(ρ_e is the mass density of the particle.)

If the scattering medium consists of spherical particles of an average atomic scattering factor per unit volume, $n'(\bar{f}_1' + i\bar{f}_2')$ imbedded in a material of that equal to $n(\bar{f}_1 + i\bar{f}_1)$, it can be shown that the kinematical result, Eq. (13), will obtain if we simply replace nf_1 and nf_2 by the difference parameters, $(nf_1 - n'f_1')$ and $(nf_2 - n'f_2')$. For voids, $f_1' = f_2' = 0$.

If the transmission sample is sufficiently thick so that multiple scattering is significant, the angular distribution of the intensity is broadened over that predicted by Eq. (13). This effect is discussed in Ref. [24].

D. SPECULAR REFLECTION BY X-RAY MIRRORS

As noted above, Smirnov [21] has expressed the Darwin-Prins difference equations as differential equations descriptive of the reflection and transmission for a continuous set of planes with spacing between the atomic reflecting planes that is small as compared with the wavelength. (He describes this case as the zero-order Bragg reflection.) After deriving the expression for total reflection from a perfectly smooth interface that reduced immediately to that predicted through the Fresnel equations (E & M boundary value solution), Smirnov et al. [28] then extended these calculations to predict the effect of surface roughness upon x-ray mirror reflection and thus explain the often observed departures of some experimental curves from the Fresnel curves.

For the low energy x-ray region, it is important not to assume that the specular reflection occurs only for the small glancing angles as is usually assumed. [2, 3,21,28] In order to obtain a precise large angle solution for the reflection of low energy x-rays, the author [22] has specialized the rigorous and general solutions of Mahan [29] for the reflection of a plane electromagnetic wave from a semi-infinite homogeneous, absorbing medium. We have shown in that solution that for the x-ray region, the reflection equation can be expressed completely in terms of a complex dielectric constant given by

$$K = 1 - (1 - \epsilon) - \frac{i2\sigma}{\nu} = 1 - \alpha - i\gamma \qquad (16)$$

(using here only, Mahan's notation). ϵ is the dielectric constant, σ the conductivity constant and ν the radiation frequency.

This dielectric constant may be derived from the dipole moment per unit volume within the medium through the usual relation

$$K = 1 + \frac{4\pi M}{\mathcal{E}},$$

BERYLLIUM MIRROR REFLECTIVITY

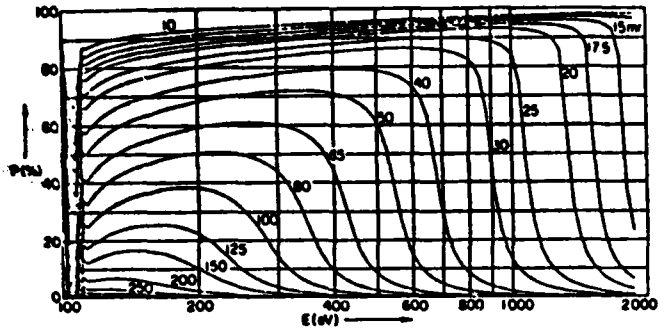


Figure 9

NICKEL MIRROR REFLECTIVITY

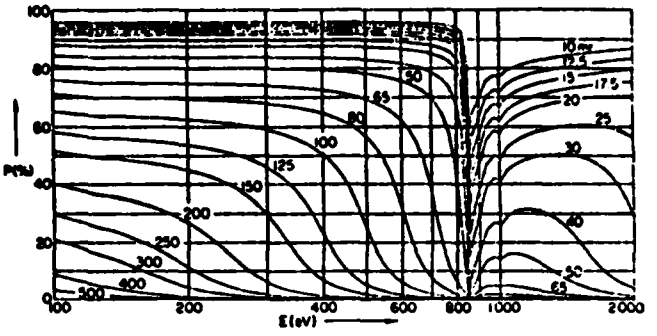


Figure 10

where E is the electric incident field. And this dipole moment per unit volume, M, can be expressed as a sum of the atomic dipole moments which are proportional to the atomic scattering factors. We can thus derive

$$\alpha = \frac{r_e\lambda^2}{\pi} n\bar{f}_1 \qquad \gamma = \frac{r_e\lambda^2}{\pi} n\bar{f}_2 \tag{17}$$

which relations also follow from Eqs. (1) through (4) (deduced by comparing the E & M and atomic scattering solutions).

We may now write Mahan's reflection intensity as specialized for large angle, low energy x-ray reflection as a function of a convenient parameter, ρ, defined by

$$\rho^2 = \tfrac{1}{2}(\sin^2\theta - \alpha + \sqrt{(\sin^2\theta - \alpha)^2 + \gamma^2}\,). \tag{18}$$

Here θ is the grazing incidence angle and α and γ are given by f_1 and f_2 through Eq. (17). (For small θ, α and γ, the parameter, ρ, becomes equal to the internal angle that the refracted beam makes with the reflecting surface.)

We define I_π and I_σ as the ratios of the reflected intensity to the incident intensity for the polarized components with the E-vector perpendicular to and parallel to the plane of reflection respectively. We may then write

$$I_\sigma(\theta) = \frac{4\rho^2(\sin\theta - \rho)^2 + \gamma^2}{4\rho^2(\sin\theta + \rho)^2 + \gamma^2} \tag{19}$$

and for the polarization ratio

$$\frac{I_\pi(\theta)}{I_\sigma(\theta)} = \frac{4\rho^2(\rho - \cos\theta\cot\theta)^2 + \gamma^2}{4\rho^2(\rho + \cos\theta\cot\theta)^2 + \gamma^2} \tag{20}$$

and finally for the total reflected intensity for an unpolarized incident beam

$$I(\theta) = \tfrac{1}{2}I_\sigma(1 + I_\pi/I_\sigma). \tag{21}$$

We have shown from Mahan's exact solution that the absorption factor in the Poynting vector that describes the energy flow of low energy x-rays into the medium is equal to $\exp(-2\pi\gamma z/\lambda\rho)$ where z is the penetration depth as measured normally to the reflecting surface. We may therefore define a 1/e depth involved in x-ray reflection by the relation

$$d_{1/e} = \frac{\lambda\rho}{4\pi\gamma} \tag{22}$$

In Ref. [1] we have applied this description of the reflection of low energy x-rays from perfectly smooth interfaces to establish detailed tables in photon energy and reflection angle for the mirrors beryllium, carbon, aluminum oxide, aluminum, fused quartz, nickel, copper and gold. As examples of such calculations we present here in Figs. 9 and 10 the reflectivity curves for beryllium and for nickel. In a companion paper of these proceedings, we also present the reflectivity-vs-θ curves for those characteristic long wavelengths for which we could also include reported experimental points for comparison.

D. BRAGG REFLECTION FROM MULTILAYERS AND CRYSTALS

Using the elementary interaction as described in Fig. 7 for a plane wave reflecting and transmitting at a single layer of unit cell structures, Compton and Allison have followed a Darwin-Prins approach to proceed to write equations for the total transmitted and reflected waves that obtain for any arbitrary, successive set of planes within a crystal of an infinite number of planes and of spacing equal to d. These difference equations were then solved with the following important results.

We define the incident amplitude of the plane wave as T_0 and the total reflected wave amplitude leaving the surface as S_0. It is shown that the total transmitted wave proceeding into the crystal that reaches the Nth layer (including the contributions of all possible multiple reflections) may be given simply by

$$T_N = T_0 x^N, \tag{23}$$

where the attenuation factor per layer, x, is assumed to be only slightly less than unity and thus we may define x here by

$$x = (-1)^m e^{-i\eta}, \tag{24}$$

where m is the order of diffraction and

$$\eta = \mp\sqrt{s^2 - (\sigma + \xi)^2} \tag{25}$$

and

$$\xi = \frac{2\pi}{\lambda} d(\sin\theta - \sin\theta_0) \tag{26}$$

(θ_0 is defined by the Bragg relation, $m\lambda = 2d\sin\theta_0$.) In Eq. (25) we choose the plus or minus sign so that the real part of η will have the (physically significant) positive value. It also follows as suggested in Fig.11 that the total wave amplitude at the Nth layer that is proceeding upward in the Bragg reflected direction (including all multiple interference contributions) may be written as

$$S_N = S_0 x^N. \tag{27}$$

The solution of the self-consistent difference equations for the ratios of the total reflected to incident amplitudes at the crystal surface and at the Nth layer are given by

$$\frac{S_0}{T_0} = \frac{-s}{(\sigma + \xi) \mp \sqrt{(\sigma + \xi)^2 - s^2}} = \frac{S_N}{T_N}. \tag{28}$$

Finally, by taking the modulus squared of the amplitude ratio as a function of the angle, θ, here in

N-DEPENDENT DARWIN-PRINS MODEL

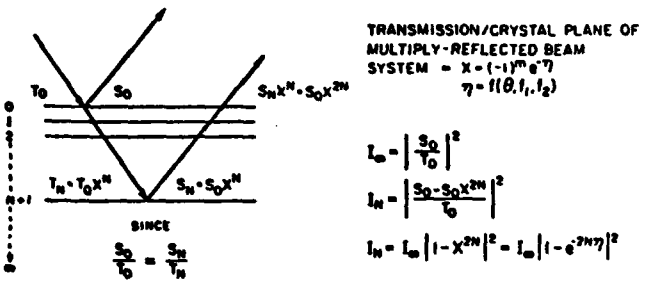


Figure 11

terms of the atomic scattering factors,

$$I_\infty(\theta) = \left| \frac{-s}{(\sigma + \xi) \mp \sqrt{(\sigma + \xi)^2 - s^2}} \right|^2 \qquad (29)$$

We would like now to apply this Darwin-Prins approach (difference equation solution for small values of σ and s) as outlined above in order to estimate the effect of limiting the crystal or multilayer to a finite number of layers, N. We suggest that the total amplitude of reflection for this finite system should be that reflected for the infinite-layer system minus that total wave amplitude reflected from the multilayer system from N+1 to ∞. Because S_0/T_0 and S_N/T_N both describe the amplitude ratios from a surface above an infinite number of layers, these must be equal. And because S_N must also be attenuated by the same factor, X^N for its value at the surface, we then obtain (as presented in Fig. 11) the amplitude ratio for the first N layers as approximately:

$$\left(\frac{S_0 - S_0 x^{2N}}{T_0}\right) \approx \frac{S_0}{T_0}(1 - x^{2N}). \qquad (30)$$

(See note added in proof.*)
Finally we may write for a modified Darwin-Prins expression for a finite number of layers, N

$$I_N(\theta) = I_\infty |(1 - e^{-2N\eta})|^2 . \qquad (31)$$

Because, for practical crystal systems, the intensities are significantly large only at angle, θ, near the diffraction peak, we may, with good approximation, rewrite the expressions for the structure factor per unit volume to be used in calculating these reflection intensities and as given in Eqs. (8) and (9) with θ set equal to the Bragg angle, θ_B defined by $m\lambda = 2d \sin\theta_B$. These become

$$\phi F_1 = \frac{1}{Ad} \sum_p x_p f_{1p} \cos \frac{2\pi m z_p}{d} \qquad (32)$$

and

$$\phi F_2 = \frac{1}{Ad} \sum_p x_p f_{2p} \cos \frac{2\pi m z_p}{d} . \qquad (33)$$

For the sputtered/evaporated multilayer systems consisting of successive double layers of thickness, d, with a "heavy" layer of thickness Γd and scattering factor per unit volume, $n(f_1 + if_2)$ and a "light" layer of thickness $1 - \Gamma d$ and of scattering factor per unit volume $n'(f_1' + if_2')$ we obtain from an integral equivalent of Eqs. (32) and (33) for such a system of continuous layers the following for the structure factor per unit volume.

$$\phi F_1 = \frac{1}{\pi m} (nf_1 - n'f_1') \sin\Gamma m\pi \qquad (34)$$

and

$$\phi F_2 = \frac{1}{\pi m} (nf_2 - n'f_2') \sin\Gamma m\pi . \qquad (35)$$

Lee [30] has recently reported an E & M boundary value solution for the periodic multilayer systerm as defined above using a characteristic matrix approach (CMA-Lee). He has shown that this rigorous solution for the intensity distribution at a diffraction peak will reduce to the Darwin-Prins expression for I_∞, and that another relatively simple modified form of the Darwin-Prins equation can be written with a correction term that introduces a dependence upon a finite number of layers, N. These results have also been discussed in Ref. [1].

It is of interest to compare reflectivity curves for multilayer systems as predicted by the modified Darwin-Prins expression given in Eq. (31) (DP-Henke) with the rigorous result (CMA-Lee) and its reduced version (DP-Lee). These comparisons are presented in Fig. 12. These were calculated for the reflection of O-Kα (23.6 A/525 eV) radiation from a tungsten/carbon multilayer of 2d = 40 A, Γ = 0.3 and for N equal to 30 and 100. It is interesting to note that the three descriptions yield essentially the same diffraction line widths and the modified Darwin-Prins expressions give somewhat higher peak values and consequently slightly higher integrated reflectivities.

As noted earlier, Smirnov et al. [28] have found the Darwin-Prins approach to be very effective in an analysis for the effects of surface roughness in x-ray reflection. They have shown that the same effects can be produced by a suitably chosen graded density interface as by a given surface roughness structure. It is suggested here that the sputtered/evaporated multilayer systems such as tungsten/carbon may exhibit changes in their reflectivity characteristics which can be explained either by interface roughness or equivalently by a graded tungsten carbide interface. For example, some of the tungsten/carbon multilayer systems which we have characterized spectroscopically have yielded essentially no high-order reflections for what were fabricated as Γ = 0.5 multilayers. As may be noted from Eqs. (34) and (35), such multilayers should have zero intensity even-order reflections only if the interfaces are sharply defined. However, if we assume that the scattering factor per unit volume with the double layer varies sinusoidally, we calculate by integration

COMPARISON OF MULTILAYER MODEL CALCULATIONS

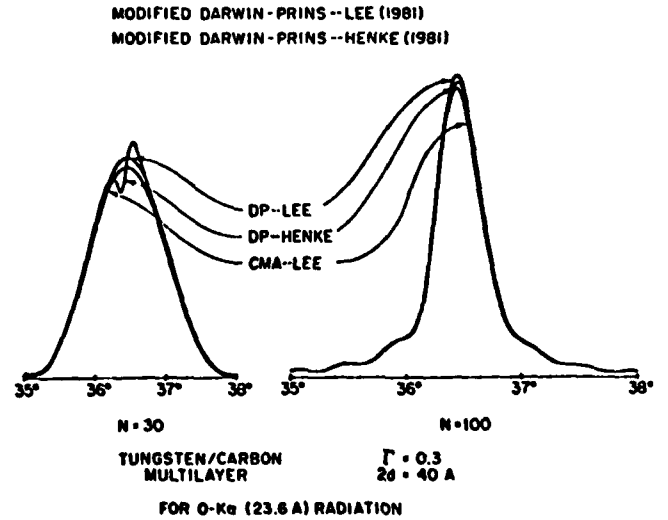
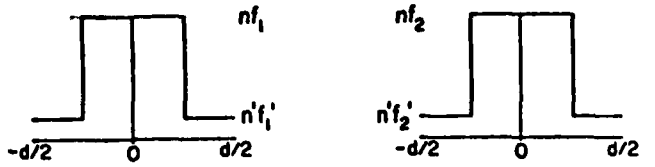


Figure 12

EFFECTS OF INTERFACE DIFFUSION

UPON THE STRUCTURE FACTOR/UNIT VOLUME -- $\phi F_1 + i\phi F_2$
AND THE ATOMIC SCATTERING FACTOR/UNIT VOLUME, $nf_1 + inf_2$

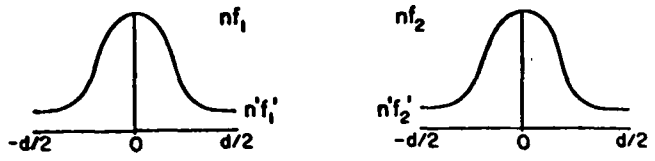
— SHARPLY DEFINED INTERFACE —



$$\phi F_1 = \frac{nf_1 - n'f_1'}{\pi} \qquad \phi F_2 = \frac{nf_2 - n'f_2'}{\pi}$$

$\phi F_1 = \phi F_2 = 0$ FOR EVEN ORDERS ONLY

— SINUSOIDALLY DIFFUSED INTERFACE —



$$\phi F_1 = \frac{nf_1 - n'f_2'}{4} \qquad \phi F_2 = \frac{nf_2 - n'f_2'}{4}$$

$\phi_1 F_1 = \phi_2 F_2 = 0$ FOR ALL HIGH ORDERS

Figure 13

---

a structure factor per unit volume that is of zero value for all high order reflections. In Fig. 13 these structure factors per unit volume for the sharply defined multilayer and for the corresponding diffused multilayer are presented. In Fig. 14 we show the calculated integrated reflectivities (R) and the diffraction line widths (ΔE) using the modified Darwin-Prins expression with ϕF values for the two types of interface and compare these with our experimental data for the same multilayer system.

Many practical crystal and multilayer systems may also have a mosaic structure (illustrated schematically in Fig. 15) consisting of small crystal segments which, however, are usually large as compared with the wavelengths involved, and the normals to each crystal segment face have a random, small angle distribution about an average normal to the macroscopic total crystal surface. The width of the associated rocking curve, $I(\theta)$, from

COMPARISON OF CALCULATED & EXPERIMENTAL FOR INTEGRATED REFLECTIVITY, R, AND ENERGY RESOLUTION, ΔE

TUNGSTEN/CARBON MULTILAYER, 2d=44.2 A, N=62, Γ=0.5

CALCULATED-- (1) SHARPLY DEFINED AND
(2) DIFFUSED INTERFACES

EXPERIMENTAL • HENKE, et al. (1980)

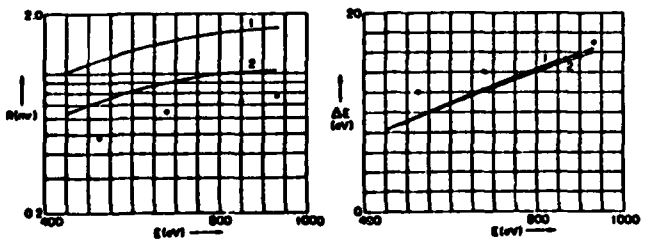


Figure 14

such a mosaic crystal is thereby increased by this angular distribution width which is usually not predictable. Nevertheless, the total area under the rocking curve, i.e., the integrated reflectivity, is not dependent upon the degree of mosaic alignment and can be simply calculated using a kinematical model. This is because one may usually assume that the crystal segment thickness is such that each atomic plane receives essentially the same incident intensity (negligible absorption within the crystallite). Summing over the differential amplitudes for the small crystal to obtain the amplitude of reflection and then squaring to obtain the intensity of reflection per crystal segment, adding these intensities over the mosaic collection (assuming their amplitudes are in random phase) and finally integrating over angles the integrated reflectivity for a mosaic crystal, R_m, is obtained [2,3] which may be written as

$$R_m = \frac{r_0^2 \lambda^4 [(\phi F_1)^2 + (\phi F_2)^2]}{16\pi\beta} \left[1 - \exp\left(-\frac{2\mu\rho t}{\sin\theta_0}\right)\right] \times \frac{1 + \cos^2 2\theta_0}{\sin 2\theta_0}, \qquad (36)$$

where, for a finite mosaic crystal, μ, ρ and t are the mass photoionization cross section, the average density and the thickness, respectively.

In Ref. [1] we have presented detailed tables and plots characterizing for examples each of the three important, practical and systems that are effective in low energy x-ray spectroscopy, viz., the sputtered/-evaporated multilayers molecular multilayers (Langmuit-Blodgett type) the acid phthalate

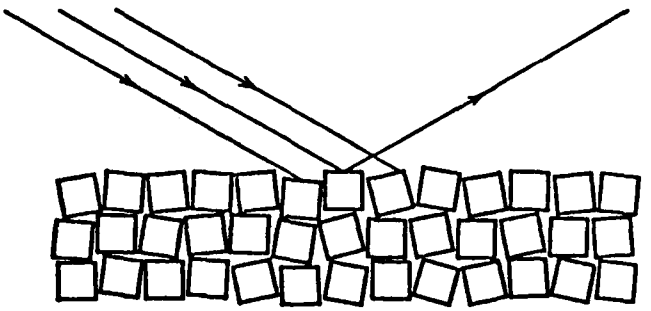


Figure 15

crystals. Presented here in Figs. 16, 17 and 18 are examples of such calculations using the methods and the atomic scattering factors as described here. The calculated characteristics for the tungsten/carbon multilayer, the lead myristate molecular multilayer and the thallium acid phthalate crystal plotted here are the integrated reflectivities, R_m, in milliradians (mosaic) and R_p (by integrating under the modified Darwin-Prins rocking curve), the percent reflectivity, P(%), at the diffraction peak, the full-width-at-half-maximum of the rocking curve in eV, and the resolving power $E/\Delta E$.

Finally it is of considerable current interest in x-ray optics development to determine the characteristics of Bragg reflection from multilayers and crystals at near normal incidence (for example, for possible applications in x-ray interferometers, for end "mirrors" in x-ray laser cavities, or for reflective coatings for normal incidence mirror optics for x-ray telescopes and microscopes). At near-normal incidence, the width of the diffraction pattern for a given wavelength becomes

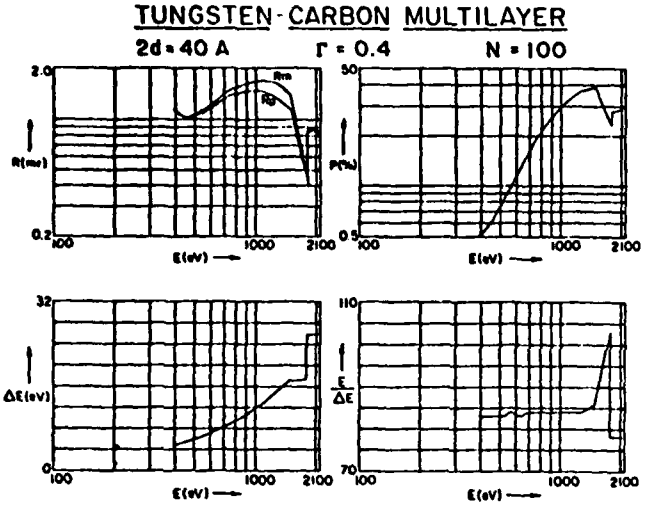


Figure 16

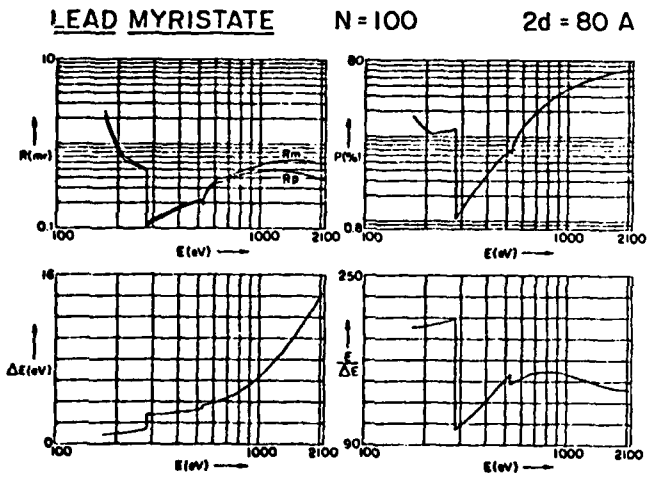


Figure 17

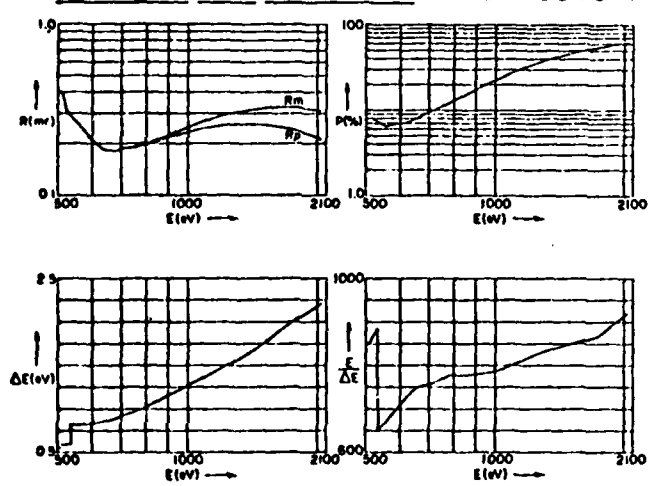
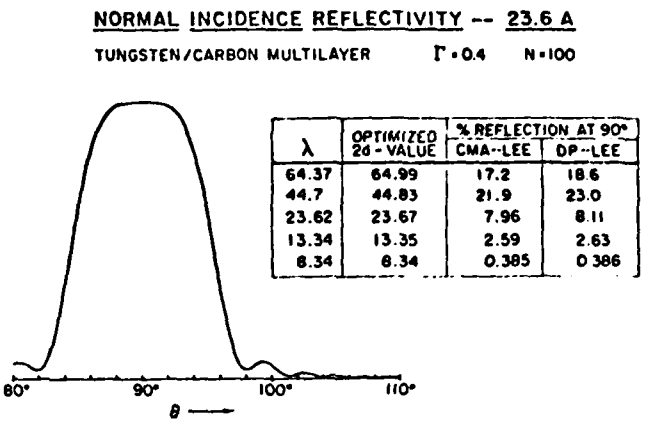


Figure 18



λ	OPTIMIZED 2d-VALUE	% REFLECTION AT 90°	
		CMA--LEE	DP--LEE
64.37	64.99	17.2	18.6
44.7	44.83	21.9	23.0
23.62	23.67	7.96	8.11
13.34	13.35	2.59	2.63
8.34	8.34	0.385	0.386

Figure 19

appreciably broadened and it is important not to approximate ξ as given exact in Eq. (26) in terms of the difference angle, $\theta - \theta_0$, as is usually done in x-ray Bragg reflection descriptions. [2,3] If the diffraction width is appreciably broadened, it may be important not to use the approximate expressions (32) and (33) for the structure factor components but rather the exact expressions (8) and (9). It may not be sufficiently accurate to discard terms of higher order than ξ^2 in either the characteristic matrix approach [30] or in the Darwin-Prins approach for normal incidence reflection calculations, form-factor corrected atomic scattering factor data. (See Appendix.)

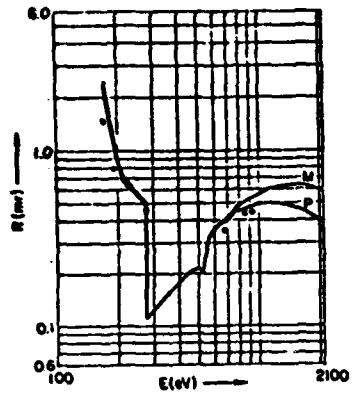
As an example of a normal incidence calculation, we have calculated the rocking curve at about $\theta = 90°$ for a multilayer of tungsten/carbon of $\Gamma = 0.4$. The 2d values were obtained for each of five wavelengths in the low energy x-ray region by maximizing the respective intensities for 90° incidence. We have used the CMA model relation of Lee [30] for these calculations and have plotted the diffraction curve for O-Kα (23.6 A/525 eV) and have compared the wavelengths with the optimized 2d-values in Fig. 19.

III. CONCLUSIONS--SOME COMPARISONS WITH EXPERIMENT

The predictions of the characteristics of Bragg reflection from multilayers and crystals are usually very sensitive to the appropriateness of the models that are adopted and to the atomic scattering factor data that is used. The experimental characterization of these systems can thus be an important test of the methods and of the atomic scattering factor data that have been presented here.

At this time, it is not possible to define accurately the detailed structure of the "synthetic crystals" such as the sputtered/evaporated and the molecular multilayers as we might crystallographically for the acid phthalate crystals, for example. Nevertheless, within the limits of experimental uncertainty, we feel that the agreement of the present experimental data with the calculations that have been described here has been generally very good.

In Fig. 14 we have presented a comparison of the measured values for the integrated reflection from a tungsten/carbon multilayer system. Here we have addressed the question as to the effect of a possible interface roughness or, equivalently, a graded tungsten carbide diffused interface upon the integrated reflectivity (for which the experimental values invariably fall somewhat below predicted values for the sputtered/evaporated systems). In Figs. 20 and 21 we present the integrated reflectivities vs photon energy for the molecular multilayer, lead myristate, and for the potassium acid phthalate crystal as calculated by the mosaic model and by the modified Darwin-Prins model. We compare these theoretical curves with our experimental values.

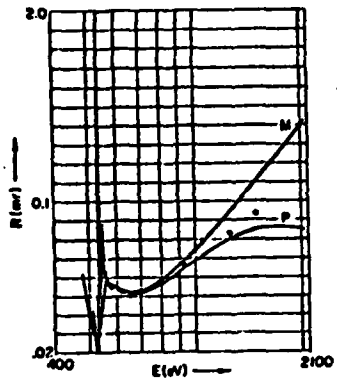


INTEGRATED REFLECTIVITY, R
LEAD MYRISTATE
(200 d-SPACINGS)

THEORETICAL
M--MOSAIC P--DARWIN-PRINS

EXPERIMENTAL
• HENKE, et al (1980)

Figure 20



INTEGRATED REFLECTIVITY, R
POTASSIUM ACID PHTHALATE (KAP)

THEORETICAL
M-- MOSAIC P--DARWIN-PRINS

EXPERIMENTAL
—— BLAKE, et al (1979)
• HENKE, et al (1980)

Figure 21

It is very important to note here, in Fig. 21, that the measured integrated reflectivity curve near the oxygen-K absorption edge (Blake et al.[31]) reveals a very sharp "spike" in the reflection at about 532 eV. This is a rather dramatic example of threshold structure that cannot be predicted with the calculated scattering factor data as has been discussed in Sec. I. Such effects may need to be explained on the basis of a detailed consideration of the electronic states of the crystal including excitonic. Presented elsewhere in these proceedings by R. L. Blake will be a complete description of the excellent measurements of this threshold resonance reflection effect.

ACKNOWLEDGEMENTS

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APPENDIX I: RELATIVISTIC AND CHARGE DISTRIBUTION CORRECTIONS FOR THE LOW ENERGY X-RAY ATOMIC SCATTERING FACTOR

Anomalous dispersion can effect an appreciable reduction in the absolute magnitude of the scattering factor and the small relativistic and charge distribution effects can then become of significant relative importance. Usually, with sufficient accuracy, these effects can be taken into account by subtracting two small correction terms from the real part of the atomic scattering factor, f_1 (as defined and tabulated here for the long wavelength and/or small angle scattering). The modified scattering factor then becomes:

$$f = f_1 - \Delta f_r - \Delta f_\theta + i f_2 \ . \qquad \text{(A1)}$$

The relativistic correction, Δf_r, depends upon Z only, and is equal to $5/3(|E_{tot}|/mc^2)$, where E_{tot} is the total energy of the atom. It has been tabulated for Z = 3 to Z = 98 by Cromer and Liberman [4]. The charge distribution correction, Δf_θ, is defined here by the quantity, $Z - f_\theta$, where f_θ is the atomic form factor which may be defined by the integral

$$f_\theta = \int_0^\infty U(r)\frac{\sin\mu r}{\mu r}\, dr \ . \qquad \text{(A2)}$$

(See Ref. 2, p. 125: U(r) is the radial charge distribution, assumed to be spherically symmetric, and the parameter, μ, is equal to $4\pi\sin\theta/\lambda$.) The form factor, f_θ, has been tabulated by Hubbell and Overbo [32] and by Hubbell, et al [33] for Z = 1 to Z = 100. [Note: θ (Hubbell) = 2θ (Henke).] $f_\theta = Z$ for $\sin\theta/\lambda << 1$. For 10 A x-radiation that is backscattered, the f_θ-values are about 0.9 Z for most elements.

This method for correcting the atomic scattering factor, $f_1 + if_2$, to account for the charge distribution has been suggested by James (Ref. 2, p. 145-6). For the low-energy x-ray region, it yields results that are in satisfactory agreement with the results of the exact (but considerably more complicated) calculations discussed recently by Kissel, Pratt and Roy [34] and Parker and Pratt [35].

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* Note Added in Proof: For small N, the reflected amplitude and intensity given by Eqs. (30) and (31) depart somewhat from these quantities as given by an exact description of a finite multilayer or crystal, but only in the region near the center of the diffraction peak. This is illustrated by the "squiggle" at the peak for the 30 layer system shown in Fig. 12. For a relatively large number of layers, I_N as given by Eq. (31) is in good agreement with that predicted by the CMA approach as illustrated in Fig. 12 for the 100 layer system. Our approximation in deriving Eq. (31) was to use for the attenuation of a transmitted beam through N layers the quantity x^N in which x was deduced for a system of an infinite number of layers. That is, x included the interaction by multiple interference of the first N layers with the layers $N+1 \ldots \infty$. A. Rosenbluth, in a private communication, has verified this fact by showing that the more exact I_N expressions (given by Eq. (9) of the Rosenbluth and Forsyth paper of these Proceedings, and by Eq. (16) of Lee [30]) does become essentially equal to that given here in Eq. (31) for the wings of the diffraction peak and, for large N, at the center of the peak as well.

Low Energy X-Ray Spectroscopy with Crystals and Multilayers

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ABSTRACT

The molecular and sputtered/evaporated multilayers and the acid phthalate crystals can be applied for relatively fast, high efficiency spectral analysis of constant and pulsed low energy x-ray sources in the 100 to 2000 eV region. Limits of resolution are about 1 eV. Reviewed here are the basic methods for the theoretical and the experimental characterization of these analyzers as required for absolute x-ray spectrometry. The design and absolute calibration of spectrographs for pulsed low energy x-ray source diagnostics are described.

I. INTRODUCTION--GRATING VS BRAGG SPECTROMETRY

Generally, the grazing incidence, diffraction grating spectrometry and the large angle Bragg diffraction spectrometry are complementary. Grating spectrographs can yield lower limits of resolution (<0.1 eV) but with relatively small aperture and low dispersion. The crystal/multilayer spectrographs are of higher limits of resolution (>0.5 eV) but with simpler and more flexible large angle geometry and with high dispersion. The crystal/multilayer spectrographs are of large aperture with an overall spectrographic speed that is considerably higher for constant source and somewhat higher for pulsed source spectroscopy. A precise intensity and window profile calibration of the crystal/multilayer instrument is more easily attainable. Having accurately characterized instrument window functions permits an effective resolution enhancement in the crystal/multilayer spectrometry by simple deconvolution procedures. The two spectrographic approaches are clearly complementary, and, ideally, both the grating and the crystal/multilayer spectrographs should be applied for an optimized analysis of many spectroscopic problems. (For a comprehensive review of grating spectrometry, see that by E. Källne in these Proceedings.)

Even with very intense excitation sources such as some synchrotron/storage ring and high temperature plasma sources, it may be that the crystal/multilayer spectrographs must still be used because the number of photons actually available for proper spectroscopic analysis is limited by other factors. The higher spectrographic speed may be required to achieve satisfactory statistics along with high temporal resolution in time-resolved spectroscopy. Primary monochromators may be required for needed selective excitation of spectroscopic samples which in turn may seriously limit the intensity available for high resolution spectroscopy. Finally, the spectroscopic sample may suffer appreciable radiation damage under the excitation dose that may be required for a given spectrographic measurement. An example of this type of problem is shown in Fig. 1. A low energy x-ray spectral analysis for the molecular orbital configuration of the crystalline solid sample of sodium perchlorate by a relatively fast, flat crystal spectrograph requires approximately three hours for one percent statistics. As shown here, with nine-minute scans through this period, the sample is steadily reduced through sucessive oxidation states with the last scan revealing the molecular orbital spectrum that is characteristic of NaCl. A successful analysis of this sample was possible [1,2] only by distributing the dosage over eight samples using selective excitation by photons of energy for which the photoionization process that is required has the highest cross section and using time resolved data collection which permitted an extrapolation to a "zero-dose" spectrum. Resolution enhancement was used to bring the energy resolution of this measurement to about 0.5 eV, using a lead myristate, molecular multilayer analyzer.

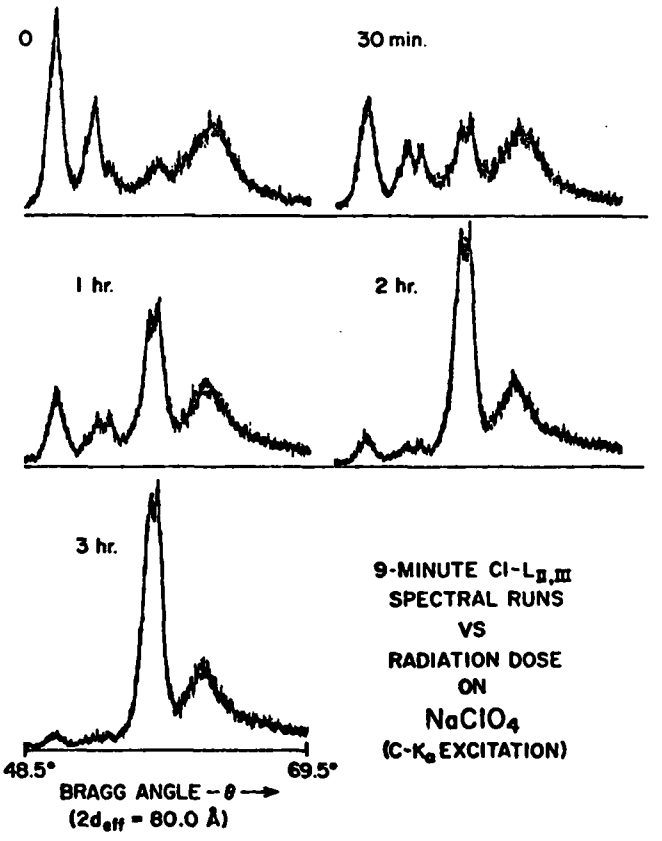
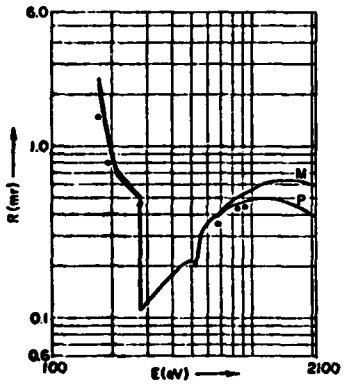


Figure 1

For high efficiency, low energy x-ray spectroscopy in the 100-2000 eV region, the sputtered/evaporated multilayers, the molecular multilayers (such as the Langmuir-Blodgett type) and the acid phthalate crystals can be used. The total intensity that may be measured within a diffracted spectral line is proportional to the integrated reflectivity, R, for the given analyzer. In Fig. 2 are plotted the integrated reflectivities for the molecular multilayer, lead myristate, and for the crystal, potassium acid phthalate (KAP), of 2d-values equal to 80 and 26.6 A, respectively. Suggested here is the fact that this type of molecular multilayer is an excellent analyzer for photon energies below 280 eV (the carbon-K edge) as is the potassium acid phthalate crystal above 530 eV (the oxygen-K edge). For the 300-500 eV region, an appropriately designed sputtered/evaporated multilayer which diffracts this spectral band around 90 degrees from the incident beam direction would be ideal. This requires a 2d-value of about 44 A for which there are no practical analyzers of the molecular or crystal types at this time.

As discussed elsewhere in these Proceedings by T. Barbee and by E. Spiller, multilayers may be constructed by either sputtering or evaporating in vacuum successive double layers of a variety of low and high atomic number materials. The thickness of the double layer (the d-spacing) may be as small as about 15 A. It should be feasible to construct spectrographic analyzers of this type that are very effective in the 300-500 eV region.

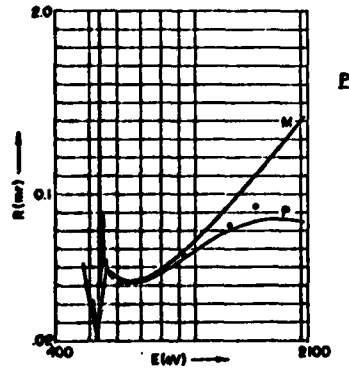
The molecular multilayers are obtained by successive dipping of a substrate in and out of a trough of water on which is formed an insoluble monomolecular film. [3] Typically, the lead salts of straight-chain fatty acids are used following procedures that were first described by Langmuir and Blodgett. [4,5,6] A schematic which suggests how these layers (Y-type) deposit upon the substrate is presented in Fig. 3. We have made low energy x-ray analyzers of this molecular type from a series of fatty acids that have 2d-values



INTEGRATED REFLECTIVITY, R
LEAD MYRISTATE
(200 d-SPACINGS)

THEORETICAL
M--MOSAIC P--DARWIN-PRINS

EXPERIMENTAL
• HENKE, et al (1980)



INTEGRATED REFLECTIVITY, R
POTASSIUM ACID PHTHALATE (KAP)

THEORETICAL
M--MOSAIC P--DARWIN-PRINS

EXPERIMENTAL
— BLAKE, et al (1979)
• HENKE, et al (1980)

Figure 2

MOLECULAR
MULTILAYER DEPOSITION
(Y-TYPE)

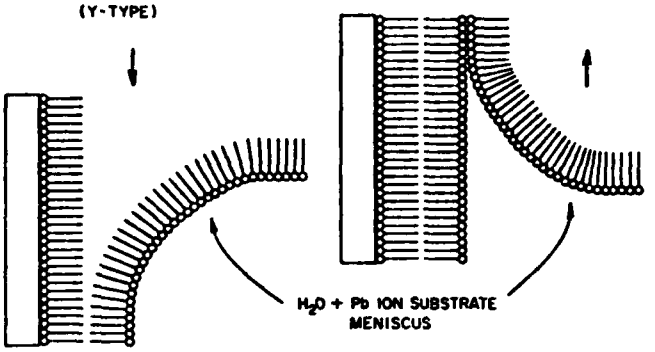


Figure 3

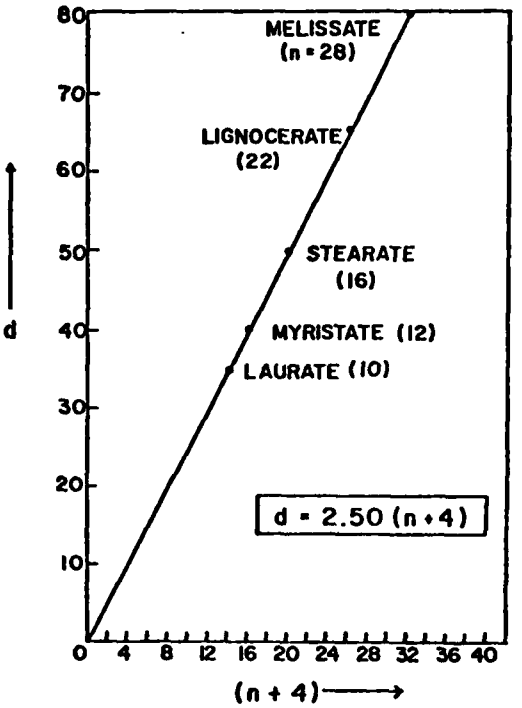
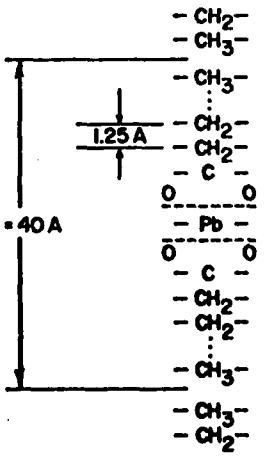


Figure 4

LEAD MYRISTATE MOLECULE



$\left[CH_3(CH_2)_{12}C\begin{matrix}O\\O\end{matrix}\right]_2Pb$

1st ORDER DIFFRACTION
STRUCTURE FACTORS

$F_1 = f_{1Pb} + 4f_{1O}\cos(2\pi|z_O|/d)$

$F_2 = f_{2Pb} + 4f_{2O}\cos(2\pi|z_O|/d)$

$z_O = 1.33$

Figure 5

in the range of 70 to 160 A. In Fig. 4 we present the measured 2d-values as a function of the number, n, of CH_2 groups of a lead salt of the straight-chain fatty acids. From this and other crystallographic data, we have constructed a model for the unit cell structure of these systems which is described in Fig. 5 and applied here in a theoretical description of their x-ray reflection characteristics.

The acid phthalate crystals have unit cell structures which have been determined by Okaya [7] and by Smith [8] which we have described and applied in our characterizations of these analyzers as recently reported elsewhere [9]. The practical characteristics of these analyzers are described in detail, experimentally and theoretically, in these Proceedings by R. Blake.

In this review we summarize some of the basic theoretical and experimental methods that may be applied to effectively characterize the crystals and multilayers for well calibrated, low energy x-ray spectrometry. And in the last section we describe spectrographs that have been specially designed for pulsed source diagnostics which utilize crystal and multilayer analyzers for the low energy x-ray region. Procedures for the application of these spectrographs for absolute, resolution-enhanced spectrometry are outlined.

II. THE THEORETICAL CHARACTERIZATION OF MULTILAYERS AND CRYSTALS FOR THE LOW ENERGY X-RAY REGION

In a companion paper in these Proceedings [10], the author has derived an expression for the analyzer reflectivity for a finite number of diffracting planes using the Darwin-Prins model. The results may be expressed in terms of complex variables in a form that is easily programmed on a small computer for effective crystal/multilayer characterization. We define:

$I_N(\theta)$: the reflectivity curve (rocking curve)--the ratio of the diffracted intensity to the incident intensity for a plane wave at a grazing angle of incidence and reflection, θ, and for an analyzer of N diffracting layers.

$I_\infty(\theta)$: the reflectivity curve for an analyzer of an effectively infinite number of diffracting layers (a thick analyzer).

s: the fractional amplitude, for a plane wave, that is reflected at each diffracting plane.

σ: the fractional decrease in amplitude of the transmitted beam as it passes through each diffracting plane.

ξ: a small quantity which measures the phase change of the wave incident at angle θ as it proceeds from one plane to the next ($2\pi d \sin\theta/\lambda$) through the relation

$$\frac{2\pi d \sin\theta}{\lambda} = \frac{2\pi d \sin\theta_0}{\lambda} + \xi = m\pi + \xi \ , \qquad (1)$$

where θ_0 is the angle defined by the Bragg relation, $m\lambda = 2d\sin\theta_0$.

η: a small quantity that is used to describe the effective attenuation of a wave as it transmits through N layers which dynamically includes all contributions from multiple reflections. The amplitude attenuation factor is x^N, where $x = (-1)^m e^{-\eta}$ and

$$\eta = \pm\sqrt{s^2 - (\xi + \sigma)^2} \qquad (2)$$

with + or - sign chosen so that the real part of η is greater than zero.

We may then write [9]

$$I_N = I_\infty |1 - e^{-2N\eta}|^2 \ , \qquad (3)$$

where

$$I_\infty = \left| \frac{-s}{(\xi + \sigma) \mp \sqrt{(\xi + \sigma)^2 - s^2}} \right|^2 \ , \qquad (4)$$

where the + or - sign is chosen so that $I_\infty < 1$.

As described in the companion paper,[10] σ and s can be calculated in terms of the average atomic scattering factor per unit volume, $n\bar{f}$, and the structure factor per unit volume, ϕF, through the relations

$$\sigma = -r_e \lambda d \frac{n\bar{f}}{\sin\theta} \qquad (5)$$

and

$$s = -r_e \lambda d \frac{\phi F}{\sin\theta} P(2\theta) \qquad (6)$$

where r_e is the classical electron radius and for the low energy x-ray region, $n\bar{f}$ and ϕF can be readily calculated given the structure of the multilayer or crystal system and using the tabulated atomic scattering factors as presented in the Appendix of these Proceedings. In the companion paper [10], $n\bar{f}$ is given by Eq. (5) and (6), and ϕF is given by Eqs. (32) and (33) for crystals and molecular multilayers and by Eqs. (34) and (35) for the sputtered/evaporated multilayers.

It should be noted that the diffraction order number, m, and the polarization factor $P(2\theta)$ are introduced through the reflection parameters, F and s. For an incident wave of electric vector in the plane of diffraction, $P(2\theta)$ is equal to $\cos 2\theta$ and for the electric vector perpendicular to the plane of diffraction, $P(2\theta)$ is equal to unity. For incident, unpolarized light, therefore, the corresponding intensity components, I_σ and I_π, are combined as

$$I_N(\theta) = \tfrac{1}{2}(I_\pi(\theta)' + I_\sigma(\theta)) \ .$$

It may be shown that the dynamical model relation for $I_N(\theta)$ given here in Eqs. (3) and (4) will reduce to the usual kinematical approximation for the analyzer of such low scattering and absorption within the layers that the incident intensity may be assumed to be the same at each plane for the given number of planes, N. Thus by assuming σ and s to be very small, $I_N(\theta)$ becomes

$$I_N = \left| \frac{-s(1 - e^{-2Ni\xi})}{2\xi} \right|^2 \ .$$

Multiplying by the complex conjugate to obtain this modulus squared, and letting ξ be replaced by $\sin\xi$ in the denominator since ξ is necessarily a small quantity for θ near the diffraction peak, we obtain for unpolarized incident radiation

$$I_N = (r_e^2\lambda^2 d^2)\frac{(\phi F_1)^2 + (\phi F_2)^2}{\sin^2\theta_0}(1 + \cos^2 2\theta)\frac{\sin^2 N\xi}{\sin^2\xi} \ . \qquad (7)$$

Because this diffraction peak will be relatively sharp, the parameter, ξ, may be written from Eq. (1) as

$$\xi = \frac{2\pi d}{\lambda}(\sin(\theta_0 + \Delta\theta) - \sin\theta_0) \approx \frac{2\pi d}{\lambda}\cos\theta_0 \Delta\theta \qquad (8)$$

and this kinematical description will assume the familiar form [12]

$$I_N(\Delta\theta) \sim \frac{\sin^2(\frac{2\pi N d}{\lambda}\cos\theta_0\Delta\theta)}{\sin^2(\frac{2\pi d}{\lambda}\cos\theta_0\Delta\theta)} \ . \qquad (9)$$

Applying the Rayleigh criterion, we define a limit of angular resolution as that $\Delta\theta_1$ which corresponds to the first minimum of this diffraction pattern. Therefore

$$\frac{2\pi N d}{\lambda}\cos\theta_0\Delta\theta_1 = \pi \text{ and } \Delta\theta_1 = \frac{\lambda}{2Nd\cos\theta_0} \ .$$

Using the Bragg relation $m\lambda = 2d\sin\theta_0$ and its derivative, we may then find the corresponding wavelength resolution as

$$\Delta\lambda = \lambda/mN \qquad (10)$$

and finally, by definition, the resolving power of this analyzer of low attenuation becomes

$$\frac{\lambda}{\Delta\lambda} = mN = \left|\frac{E}{\Delta E}\right| . \qquad (11)$$

This resolving power is then an upper limit that may be expected of a multilayer of a relatively small number of layers, N, and at diffraction order, m.

For some analyzers, particularly for very low energy x-rays and with sputtered/evaporated multilayers, the effective number of diffracting planes may be limited by absorption within the multilayer and the dependence upon N drops out for N sufficiently large but finite. If then we consider the absorptive parameter, σ, to be large as compared with the reflective parameter, s, the reflectivity curve, $I_N(\theta)$, from Eq. (3), becomes the Lorentzian function

$$I(\Delta\theta) = \frac{(\frac{\omega}{2\pi})R_m}{(\Delta\theta - \frac{\delta}{\sin\theta_\theta\cos\theta_\theta})^2 + (\frac{\omega}{2})^2} = \frac{(\frac{\omega}{2\pi})R_m}{\varepsilon^2 + (\frac{\omega}{2})^2} . \qquad (12)$$

This function will have its peak value displaced from the Bragg angle, θ_θ, by an amount equal to $\delta/\sin\theta_\theta\cos\theta_\theta$, which is a refraction shift of the diffraction pattern that may also be predicted by combining the Bragg relation with Snell's law [11,12]. It is interesting to note that this result follows here for the case of relatively high absorption within the analyzer. For this Lorentzian rocking curve approximation, its parameters may be written as follows:

The angle, ε, as measured from the diffraction peak

$$\varepsilon = \Delta\theta - \delta/\sin\theta_\theta\cos\theta_\theta . \qquad (13)$$

The full-width-at-half-maximum (FWHM)

$$\omega = 2\beta/\sin\theta_\theta\cos\theta_\theta . \qquad (14)$$

The corresponding integrated reflectivity (area under the Lorentzian) for unpolarized incident radiation

$$R_m = \frac{r_e^2\lambda^4}{16\pi\beta}[(\phi F_1)^2 + (\phi F_2)^2]\frac{1 + \cos^2 2\theta}{\sin 2\theta} . \qquad (15)$$

Here the optical constants, δ and β, are as have been defined in Ref. 10 of these Proceedings to be given by

$$\delta = \frac{r_e\lambda^2}{2\pi} n\bar{f}_1 \qquad (16)$$

$$\beta = \frac{r_e\lambda^2}{2\pi} n\bar{f}_2 .$$

The integrated reflectivity, R_m, that results from this Lorentzian, absorption-limited approximation, is idential to that which may be obtained from the mosaic crystal model [11,12] and as given in Ref. 10.

According to the mosaic crystal model, we may include the effect of a finite crystal thickness by multiplying the expression for R_m in Eq. (15) by the factor

$$(1 - \exp(-2\mu\rho t/\sin\theta_\theta))$$

in which μ is the mass photoionization cross section for the crystal material, ρ is the average mass density and t is the crystal thickness which is approximately equal to Nd. If the crystal or multilayer has a significant mosaic quality, the FWHM of its rocking curve will be greater than that expected from the perfect crystal model and will normally be determined by measurement. As is illustrated in Fig. 2, this integrated reflectivity, R_m, generally tends to be higher than R_p, that as derived by numerically integrating for the area under $I_N(\theta)$ from Eq. (3). Well defined crystals such as the acid phthalates, for example, will typically have experimentally measured values for the integrated reflectivity that fall between these values for the mosaic and the perfect crystal models.

As has been discussed in the companion paper of these Proceedings [10], this relatively simple Darwin-Prins model approach for the characterization of low energy x-ray analyzers is generally in good agreement with the rigorous E & M boundary values approach (the characteristic matrix approach) for the perfect multilayer systems. [13,14] Generally, the approximations that are inherent in the Darwin-Prins approach for the finite crystal/multilayer system as has been described here are appropriate inasmuch as the typical real crystal/multilayer system cannot be defined any more precisely than is this approximate model. In the design of low energy x-ray analyzers, particularly of the sputtered/evaporated type, this simple theoretical model can provide helpful, immediate insights as to the interplay of the electron scattering contrast yielded by the structure factors and the multilayer absorption, and their effect upon the analyzer performance. In Fig. 6 the integrated reflectivity, R_m, from the thick mosaic model, has been plotted for photon energies above the C-K edge and for a variety of practical sputtered/evaporated, equal-thickness double layers of d equal to 30 A. For these calculations, structure factors were used as for sharply defined interfaces between the 15 A layers. As has been discussed in the companion paper [10], the integrated reflectivities would be significantly reduced if a graded-density or rough interface were to be involved.

INTEGRATED REFLECTIVITY, R,
FOR
SPUTTERED OR EVAPORATED MULTILAYERS
WITH
15 A EQUAL THICKNESS LAYERS -- 2d = 60 A

(A) TUNGSTEN/BORON
(B) TUNGSTEN/CARBON
(C) MOLYBDENUM/CARBON
(D) MOLYBDENUM/TITANIUM
(E) TITANIUM/CARBON

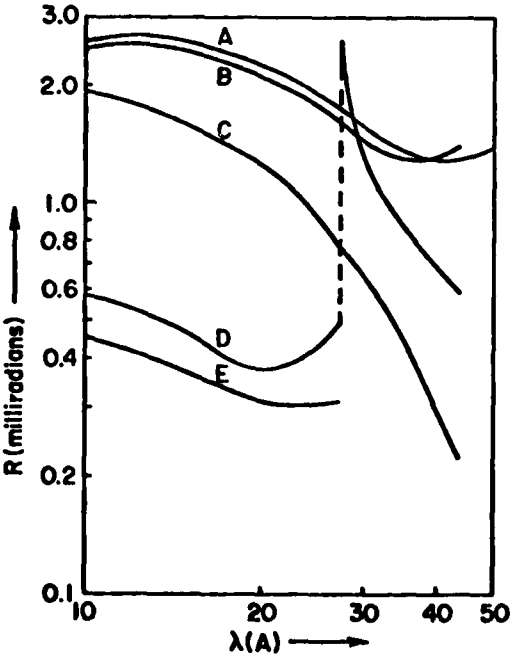


Figure 6

In Fig. 7 we compare the diffraction peak profiles for the lead myristate molecular multilayer and the tungsten-carbon sputtered/evaporated multilayer with the same 2d-value of 80 A. Here the fractional thickness of the d-spacing for the heavy layer (tungsten), defined as Γ, is varied. Again a sharply defined interface was assumed for the W/C multilayer which yields appreciably higher predicted peak intensities than are observed relative to those for the lead myristate. The measured angular widths of the rocking curves are in good agreement with these as predicted, however.

III. THE EXPERIMENTAL CHARACTERIZATION OF MULTILAYERS AND CRYSTALS FOR THE LOW ENERGY X-RAY REGION

The optimized low energy x-ray analyzer will have the maximum, effective number of layers as determined essentially by the crystal/multilayer attenuation. (N for the multilayers chosen sufficiently large.) For such analyzers the perfect crystal model relation, $I_\infty(\theta)$, presented here in Eq. (4), predicts a diffraction curve with Lorentzian wings. That is, for angles not close to the peak, ξ becomes relatively large as compared with σ and s and the intensity distribution falls off as $(\Delta\theta)^{-2}$ as for a Lorentzian. As already noted above, for many practical crystals and multilayers applied in the high attenuation, low energy x-ray region, the total profile tends to become Lorentzian.

In Ref. 9 we have calculated in detail the reflectivity characteristics vs photon energy for five acid phthalate analyzers and five each of 100-layer molecular and sputtered/evaporated (tungsten-carbon) multilayers. For such characterizations, we define the integrated reflectivity as the area under the reflectivity curve within the limits of plus/minus 5ω, (at which limits $I_N(\theta) \approx .01$). We have compared the integrated reflectivity as obtained by precise numerical integration under the theoretical reflectivity curve to that for a Lorentzian curve having the same FWHM, ω, and the same peak height as that given by $I_N(\theta)$. The two integrated reflectivities generally agree within ten percent. Finally, our measured molecular and sputtered/evaporated multilayer rocking curves, after correcting for instrumental broadening, are well described by Lorentzian fits. Similarly it has been found that the reflectivity curves for the acid phthalate crystals may be described as Lorentzian. [15]

In our experimental characterization of low energy x-ray analyzers, therefore, we assume that the reflectivity curve is essentially Lorentzian which may be then described by the relation

$$I(\varepsilon) = \frac{(\omega/2\pi)R}{\varepsilon^2 + (\omega/2)^2} . \qquad (17)$$

A. THE MEASUREMENT OF THE FWHM-ω

Our measurements of ω for a given analyzer are of a series of monochromatic line sources which are Lorentzian in their wavelength and photon energy distribution and produce an equivalent angular broadening of the spectral line equal to ε_θ. A conventional, flat crystal spectrograph is used with soller slit collimation that presents a further angular broadening of a Gaussian shape and of FWHM equal to g. Pulse height discrimination is utilized with a flow proportional counter to minimize background under the isolated spectral line.

The convolution of Lorentzians yields another Lorentzian with the widths adding linearly. The convolution of Gaussians yields another Gaussian, but with the widths adding quadratically. Because in many spectroscopic measurements the collimation is Gaussian, the measured spectral line is the result of a convolution of a Gaussian collimation function with a Lorentzian analyzer plus emission line profile. The Gaussian-Lorentzian convolution yields a Voigt curve for which there is no exact analytical function

COMPARISON OF MOLECULAR AND SPUTTERED/EVAPORATED MULTILAYERS AT Mo-Mζ (64.4 A/192.3 eV)

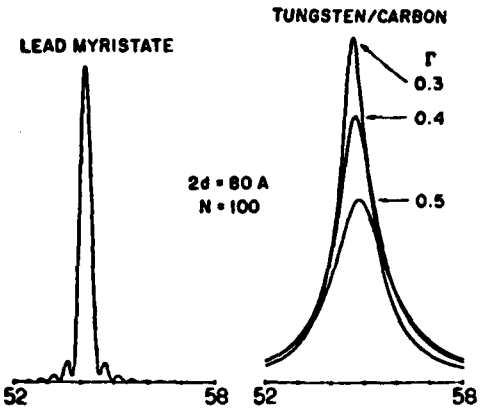


Figure 7

description.

We have shown [1] that within a sufficiently good approximation, the Voigt function can be described simply as a linear mixing of the two basic broadening functions, the Gaussian, G(x), and the Lorentzian, L(x) through the relation

$$V(x) = \delta G(x) + (1 - \delta)L(x). \qquad (18)$$

If we define the FWHM widths for the Gaussian, the Lorentzian and their fold, the Voigt function by g, ℓ and v, respectively, and the variable χ by ε/v (ε is the angle from the peak), we may then write

$$G(x) = e^{-(\ell n 2)x^2} \text{ and } L(x) = \frac{1}{1 + x^2} \qquad (19)$$

and the mixing parameter, δ, becomes

$$\delta = 1 - \ell/v \approx (g/v)^2 . \qquad (20)$$

In our crystal characterizations, ℓ represents the sum of the Lorentzian crystal multilayer and emission line widths, $\omega + \varepsilon_\theta$, and we may write for the analyzer width, ω, from Eq. (20)

$$\omega = v(1 - (g/v)^2) - \varepsilon_\theta . \qquad (21)$$

These numerically derived relationships have been tested on a series of low energy x-ray emission lines for which the natural widths have been precisely measured using photoelectron spectroscopy. [1] We illustrate in Fig. 8 how the Mo-Mζ (64.4 A/193 eV) line is used to determine the lead myristate molecular analyzer diffraction width, ω, to be 0.33° and, equivalently, in energy width, 0.82 eV. These values may be compared with those as determined from the theoretical reflectivity curve, $I_N(\theta)$, given in Eq. (3) to be 0.36° and 0.89 eV, respectively.

B. THE MEASUREMENT OF THE INTEGRATED REFLECTIVITY, R

Practical flat crystal calibration for the integrated reflectivity, R, usually involves incident beams which are neither precisely monochromatic nor parallel. Let the incident beam be of cross section that is smaller than the window area of the detector and be of total direct beam intensity P_θ counts per second. Consider the beam to be made up of a collection of rays with a narrow distribution of angular divergence about a central ray and each with intensity, $\Delta P_{\theta n}$. The intensity that is reflected for the n^{th} ray near a θ incidence angle is ΔP_n. Then if $I_N(\theta)$ is the reflectivity, we may write

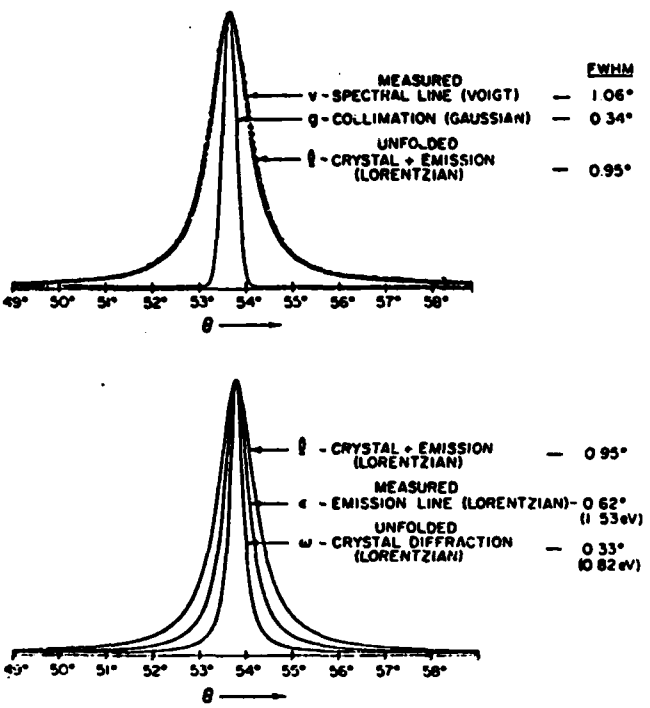


Figure 8

$$\Delta P_n = \Delta P_{en} I_N(\theta) \ .$$

Let the crystal be rotated through a range in θ that completely embraces a diffraction peak for all incident rays and at an angular rate of ω_θ. If dE_n is the total counts measured by the detector for the nth ray during interval dt, we may write

$$dE_n = \Delta P_{en} I_N(\theta) dt = \Delta P_{en} I_N(\theta)(d\theta/\omega_\theta)$$

and

$$\Delta E_n = (\Delta P_{en}/\omega_\theta)\int I_N(\theta)d\theta = (\Delta P_{en}/\omega_\theta)R.$$

Now summing over all n rays in the divergent incident beam, we obtain the total counts collected, E, as a diffraction peak is scanned as

$$E = \sum_n \Delta E_n = \frac{1}{\omega_\theta} R \sum \Delta P_{en} = \frac{P_e R}{\omega_\theta} \ .$$

And thus R may be expressed in terms of measurable quantities as

$$R = \frac{E\omega_\theta}{P_e} \ . \qquad (22)$$

If the incident beam is not precisely monochromatic, but consists of a narrow band of wavelengths about a mean value, a similar argument as presented above may be applied to yield the same result as Eq. (22), where R would then represent an integrated reflectivity characteristic of an average wavelength. This follows from the fact that the intensity distribution for a variable wavelength component is simply shifted a small amount in angle according to the Bragg relation--but still embraced in the complete scan taken over the diffraction peak. The value of R thus determined is independent of a small departure from monochromaticity of the beam--providing that the reflectivity is slowly varying over the spread in wavelengths involved.

In Figs. 9 and 10 we have applied this flat crystal calibration procedure in order to compare the performance of a molecular and a sputtered multilayer in the 500-1000 eV photon energy region. The sputtered multilayer, constructed by T. Barbee, has a 2d-value of 44.2 Å, N = 62, and Γ = 0.3. The molecular multilayer is lead myristate of 2d equal to 80 A and N = 200. These comparative spectral scans of characteristic line radiations were taken with soller slit collimation of Gaussian, FWHM value, g, equal to 0.34° in θ-coordinates. The multilayer angular width, FWHM-ω, was determined using Eq. (21), its integrated reflectivity determined by Eq. (22) and the percent peak reflectivity, P, assuming a Lorentzian reflectivity curve as in Eq. (17), and equal to $[2R/\pi\omega] \times 100$.

With calibrated crystal/multilayer analyzers, and instrument collimation window functions, and with the measured spectral line widths, Eq. (21) may then be used to determine the emission line width with enhanced resolution. We have developed a simple method for treating overlapping spectral lines [1] by fitting a sum of Voigt functions as given in Eq. (18) by a Simplex method which fitting determines the angular position, weight and width of each component lines in the overlapping spectrum. Eq. (21) is then used to determine the individual emission line widths. Again, enhanced resolution is obtained.

Often, rather than flat crystal optics with essentially parallel incident radiation, divergent beam optics (as with Johann circle geometry) or with non-focussing optics for an instantaneous presentation of an emitted spectrum (for pulsed source spectroscopy) may be used. For spectrographs using these divergent beam geometries, the measured intensity profiles for a monochromatic source may usually be predicted in terms of the flat-crystal reflectivity characteristic parameters and appropriate geometric factors. This is illustrated in the next section for the pulsed source spectrographs which utilize the cylindrical-convex crystal/multilayer and the elliptical crystal/multilayer.

IV. PULSED SOURCE SPECTROSCOPY

A. THE CONVEX CYLINDRICAL CRYSTAL ANALYZER

The convex cylindrical crystal [3,16-20] presents to an x-ray source a continuum of reflecting regions with Bragg angles beginning from zero value. For a particular wavelength, the effective aperture is proportional to sinθ and hence to mλ for the usual application geometry in which the cylinder radius, r, is small as compared with the distance to the source, s. We have constructed cylindrical analyzers of good quality by bending .005" cleaved sections of KAP to radii as small as one inch, and by dipping polished cylinder substrates of radii as small as a few millimeters to generate the Langmuir-Blodgett type of molecular multilayers. The

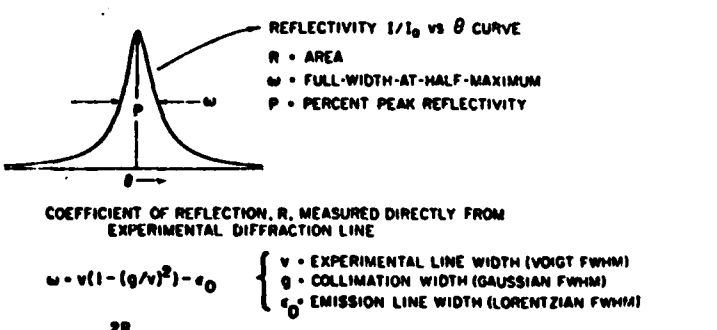
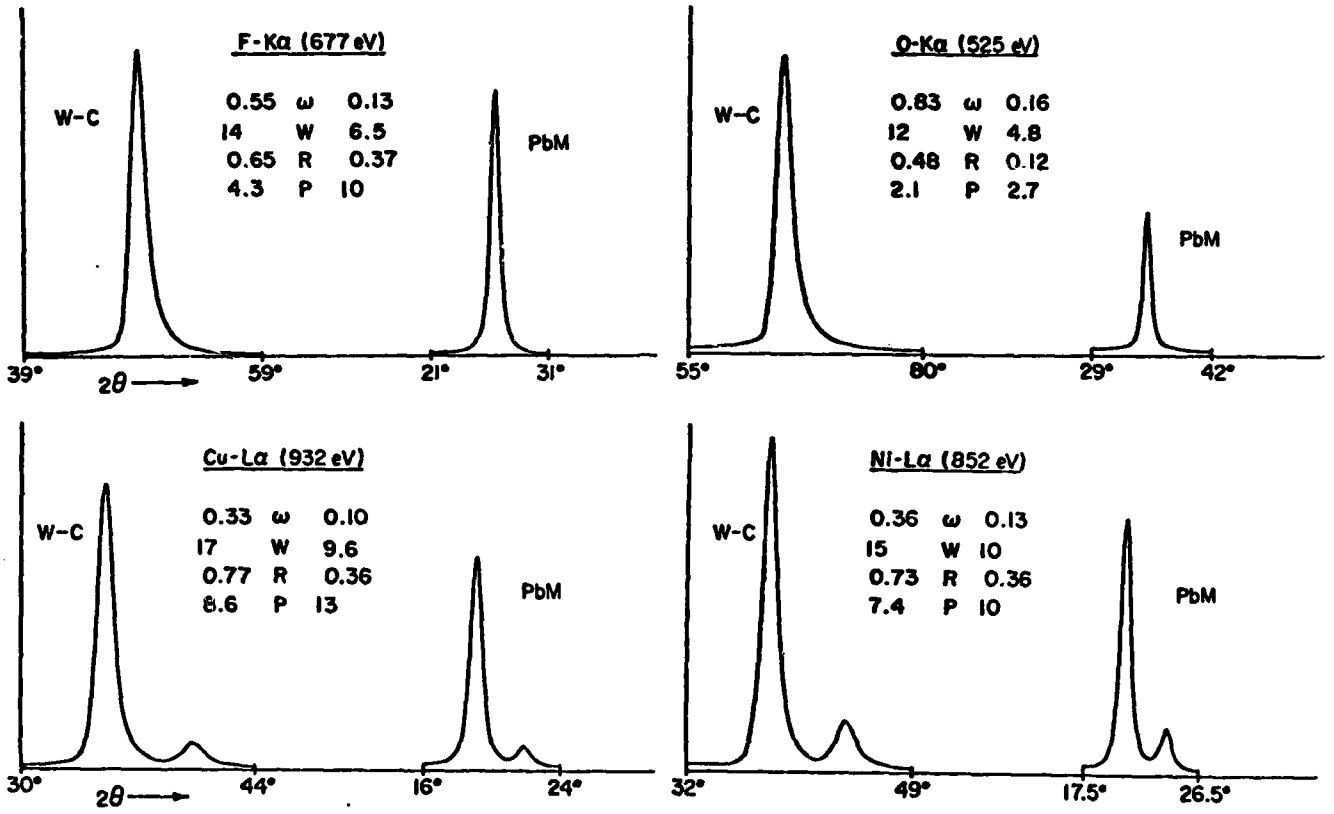


Figure 9

COMPARISON OF MULTILAYER ANALYZERS--500-1000 eV REGION

TUNGSTEN-CARBON--62 II-PLUS-II d-SPACINGS--2d = 44.2 A
LEAD MYRISTATE--200 d-SPACINGS--2d = 80 A
ROCKING CURVE FWHM--$\omega(^\circ\theta)$ AND W(eV)
REFLECTIVITY--INTEGRATED, R(mr) PEAK, P(%)



COLLIMATION FWHM (GAUSSIAN)--0.77° (2θ)

Figure 10

sputtered/evaporated multilayers may be deposited upon a flat, flexible substrate which may then be bent to a desired radius.

Some useful geometrical relations which characterize this analyzer are as follows (see Fig. 11):

$$\cos\theta = \cos\chi - (1/\delta)\sin\chi \qquad (23)$$

and

$$(d\chi/d\theta) = \delta\sin\theta/(\delta\sin\chi + \cos\chi) \qquad (24)$$

in which $\delta = r/s$. Now for $\delta \ll 1$, it follows that

$$\cos\theta = 1 - \chi/\delta \qquad (25)$$

and

$$(d\chi/d\theta) = \delta\sin\theta\ . \qquad (26)$$

To relate the reflecting region position, α, with the corresponding Bragg angle, θ

$$\alpha = \theta - \chi = \theta - \delta(1 - \cos\theta). \qquad (27)$$

And to relate the position of the detector, β, to the corresponding Bragg angle, θ--for $r \ll R$ (crystal-detector distance)

$$\beta = 2\theta - \chi = 2\theta - \delta(1 - \cos\theta). \qquad (28)$$

And, finally, for instruments with $\delta \ll 1$, a relation between the divergent beam diffraction line profile, $dN/d\theta$, defined as $P(\theta)$, produced by the cylindrical crystal and the parallel beam, flat crystal reflectivity ratio, $I_N(\theta)$, can be obtained as

$$\frac{dN}{d\theta} = P(\theta) = I(\theta)(i_e a\psi)(d\chi/d\theta) = \delta i_e a\psi \sin\theta I(\theta), \qquad (29)$$

where i_e is the number of photons per sec-unit source area-steardian, a is the source slit area, and ψ is the angle at the source slit as subtended by the crystal width, and assuming the slit thickness to be negligible.

The total number of photons, N, within the diffraction line profile is proportional to the crystal's integrated reflectivity, R, and given by

$$N = \int P(\theta)d\theta = \delta i_e a\psi\overline{\sin\theta}\int I(\theta)d\theta = \delta(i_e a\psi\overline{\sin\theta})R. \qquad (30)$$

Finally, to determine the effect of slit or line source width upon the profile, we integrate the differential intensity from a section of the slit of width, b, and differential thickness, $sd\phi$, (as reflected into the diffraction line profile) within the limits $-\phi_e$ to $+\phi_e$, where $2\phi_e$ is the angular thickness of the slit as measured at the crystal. We obtain, assuming $I_N(\theta)$ to be Lorentzian, as given in Eq. (17):

$$P'(\theta) = (\delta i_e b s\,\overline{\sin\theta})\left(\frac{\omega}{2\pi}R\right)\int_{-\phi_e}^{\phi_e}\frac{d\phi}{(\epsilon - \phi)^2 + (\omega/2)^2}.$$

CYLINDRICAL CRYSTAL GEOMETRY

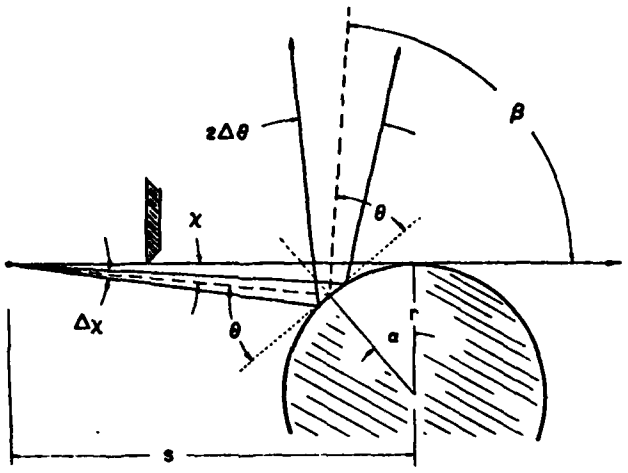


Figure 11

Thus

$$P'(\theta) = (\delta i_\theta b s \psi \overline{\sin\theta})(R/\pi)\left(\tan^{-1}\frac{\varepsilon + \phi_\theta}{\omega/2} - \tan^{-1}\frac{\varepsilon - \phi_\theta}{\omega/2}\right) \quad (31)$$

$P'(\theta)$ has been plotted for several relative values of ϕ_θ/ω in Fig. 12. If the source brightness, i_θ, is not uniform but rather is a function of ϕ, then $i_\theta(\theta)$ must be folded within the integral.

B. THE ELLIPTICAL CRYSTAL/MULTILAYER SPECTROGRAPH

Shown in Fig. 13 are the basic features of the proposed spectrograph for the spectral analysis of a pulsed low energy x-ray source. An elliptically curved crystal or multilayer analyzer is utilized with an effective point or line source at or through one of the foci and a small exit aperture (scatter aperture) at the second focal point. The elliptical analyzer curvature may be a cylindrical section, or it may be of double curvature and as a surface of revolution about the major arcs (an ellipsoidal section).

Considerable importance in the design of this spectrograph [21] has been placed upon achieving a minimum of background radiation and presenting a spectrum that can be simply and accurately interpreted to yield the source spectral characteristics in the low energy x-ray region. The small scatter aperture into the detector module effectively eliminates the stray radiation that may diffusely scatter or fluoresce from the analyzer. An optically flat or cylindrically curved total-reflection mirror with an adjustable entrance slit along with an appropriate filter is used for an effective attenuation of high-order diffracted and the lower-energy radiation background. If the slit at the mirror is adjusted for a sufficiently small entrance aperture, a one-dimensional spatial distribution of the source intensity for the particular wavelength can be presented along the length of a corresponding spectral line for an extended source (spatial resolution in the tenth milliradian range). The spectrum is formed by a relatively small analyzer dimension normal to this drawing section so that the analyzers can thus be "stacked" for multiple band spectral coverage. This is described in Fig. 14.

The elliptically curved crystal/multilayer substrates have been made by computer controlled milling and by computer controlled diamond turning of aluminum blanks.[22] The acid phthalate cleaved sections of about .005" thickness and coverslip glass of about .010" thickness are epoxied to the curved surfaces under light pressure. The molecular multilayers are deposited directly upon the coverslip glass curved surfaces. The coverslip glass pieces are preformed in an oven to fit a graphite substrate of identical shape as the aluminum substrates.

The diffraction geometry is shown in Fig. 15. In order to establish a focal point for radiation from a small source and thereby an effective scatter aperture, the analyzer curvature is that for the ellipse

$$\rho = \frac{h}{1 - e\cos\beta}, \quad (32)$$

where e is its eccentricity and h is the characteristic radial distance, ρ, from the exit focal point for $\beta = \pm 90°$.

An important design feature is that the measured radiation can be normal to a circular arc detection surface (a film surface for photographic detection, a CCD array for electronic detection and for time-resolved spectroscopy, and for a proportional counter goniometer circle in a calibration chamber.) The angular position on this detection circle, β, is related to the Bragg reflection angle off the analyzer, θ, by the equation

$$\theta = \tan^{-1}\left(\frac{1 - e\cos\beta}{e\sin\beta}\right) \quad (33)$$

which reduces to simply

$$\theta = \beta/2 \quad (34)$$

for applications with a large source distance (i.e., with an eccentricity, e, equal to unity for an approximately parabolic analyzer.

EFFECT OF SOURCE SIZE ON CYLINDRICAL CRYSTAL LINE PROFILE

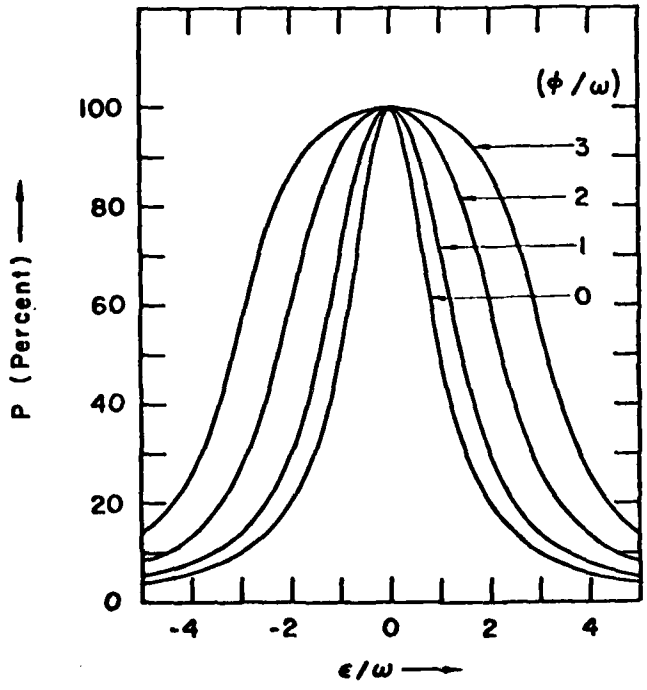


Figure 12

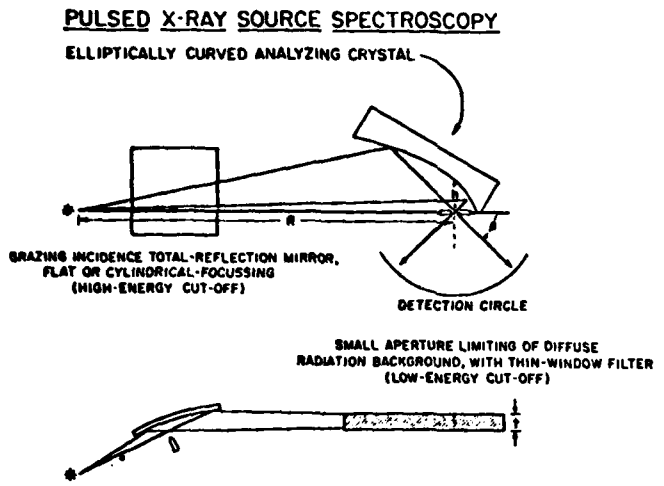


Figure 13

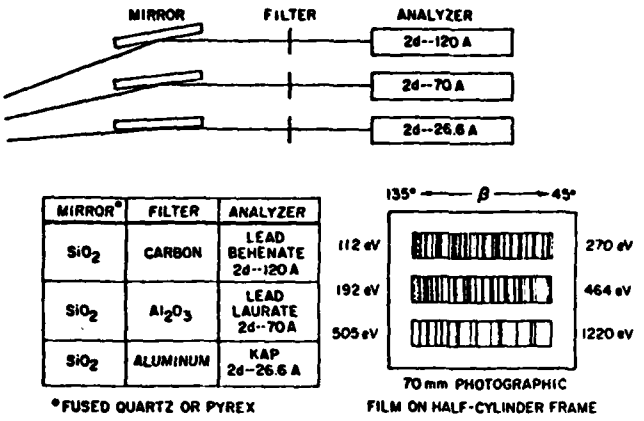


Figure 14

In Fig. 15 we define the angular position of a ray from the source, χ, which is related to θ and β by

$$\chi = 2\theta - \beta \qquad (35)$$

and thus differentially

$$\frac{d\chi}{d\theta} = 2 - \frac{d\beta}{d\theta} \ . \qquad (36)$$

And from Eq. (33) we may obtain $d\beta/d\theta$ as

$$\frac{d\beta}{d\theta} = \frac{e^2 + 1 - 2e\cos\beta}{e(e - \cos\beta)} \ . \qquad (37)$$

We would like next to write an expression for the spectral line profile as diffracted by the elliptically curved analyzer of cylindrical section in terms of the flat crystal characteristic parameters, R and ω. As we have described above for the convex, cylindrical analyzer, we shall define by dN the number of photons per sec diffracted by the elliptical analyzer within a differential angular region, $d\theta$, about a Bragg angle, θ, and equal to $P(\theta)d\theta$. Thus the divergent beam angular distribution of intensity as diffracted by the elliptically curved analyzer becomes

$$\frac{dN}{d\theta} = P(\theta) = i_0 a\psi \frac{d\chi}{d\theta} I_N(\theta) \ , \qquad (38)$$

where $\underline{a}$ is the projected source area; ψ is the angular width of the beam that is accepted by the analyzer and measured in the plane normal to the Bragg reflection plane; and $I_N(\theta)$ is the flat-crystal rocking curve, the fraction of the intensity for a parallel incident beam that is reflected at an angle, θ. Integrating Eq. (38) through the reflecting region in θ for a given wavelength, we obtain the total number of photons per second within the diffracted line as

$$N = i_0 a\psi\left(\frac{d\chi}{d\theta}\right)\int I_N(\theta)d\theta = i_0 a\psi\left(\frac{d\chi}{d\theta}\right)R. \qquad (39)$$

Finally, if we assume that the flat crystal, parallel beam rocking curve, $I_N(\theta)$, to be Lorentzian as in Eq. (17), we may write for $P(\theta)$

$$P(\theta) = i_0 a\psi\left(\frac{d\chi}{d\theta}\right) \frac{(\omega/2\pi)R}{\epsilon^2 + (\omega/2)^2} \ , \qquad (40)$$

where ϵ is measured from the position of the diffracted peak in θ-coordinates. Eq. (40) may be expressed in β-coordinates, as measured along the detection circle, by multiplying the numerator and denominator of the Lorentzian by $(d\beta/d\theta)^2$. Here, $d\beta/d\theta$ and $d\chi/d\theta$ may be expressed in variable β through Eqs. (36) and (37). We have defined by $\Delta\beta$ the angular position as measured from the peak position along the detection circle for the Lorentzian defined as follows:

$$\Delta\beta = \left(\frac{d\beta}{d\theta}\right)\epsilon \qquad (41)$$

and its measured FWHM, ϕ,

$$\phi = \left(\frac{d\beta}{d\theta}\right)\omega \ . \qquad (42)$$

The β-position for a peak of wavelength λ is obtained by inverting Eq. (33) for the refraction-shifted peak position in θ-coordinates, viz., (from Eq. (12))

$$\theta_0 + \frac{\delta}{\sin\theta_0\cos\theta_0} \ .$$

In Figs. 16, 17 and 18 are presented plots of our calculated reflectivity characteristics [9] for the three analyzers, lead behenate, lead laurate and potassium acid phthalate of 2d-values of 120, 70 and 26.6 A, respectively. We have proposed these analyzers for a three-band spectrograph for the 100-1000 eV region which has been described in Fig. 13.

In order to verify the response functions for the elliptical spectrograph as predicted here and to account for possible individual differences between the curved crystal/multilayer and the corresponding flat analyzers (on which the flat crystal characteristics have been directly measured), we measured the elliptical

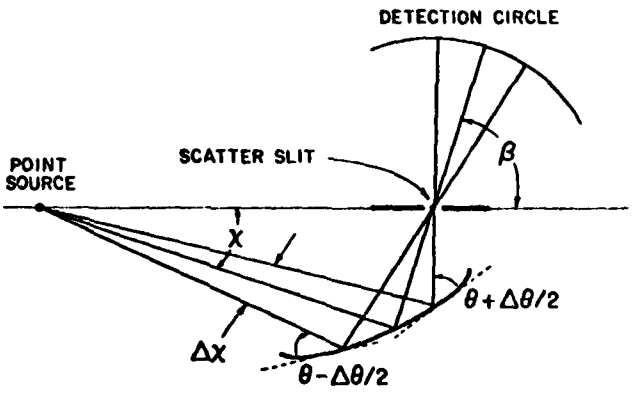


Figure 15

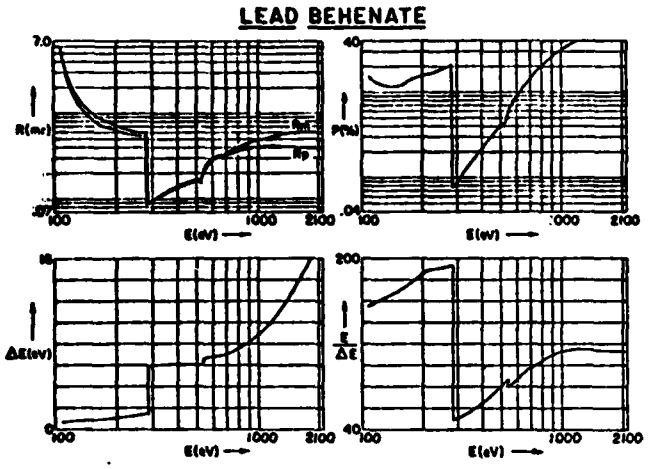


Figure 16

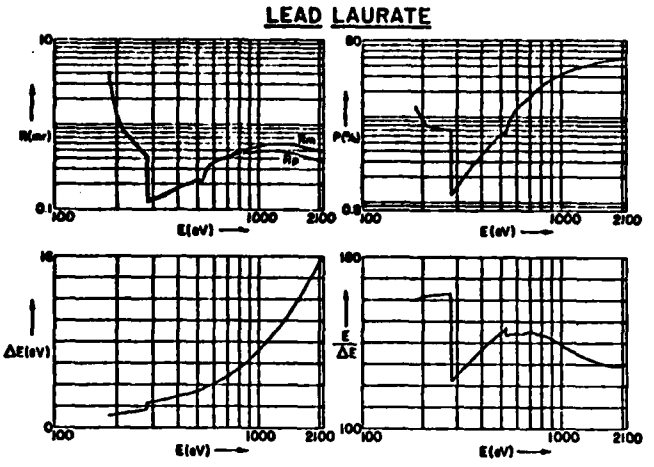


Figure 17

analyzer response function directly at a few standard wavelengths by introducing a calibrated flow proportional counter, with a precision goniometer, on the detection circle. In this way the diffraction peak is measured in β-coordinates and compared with the directly measured i_β for a characteristic line source that is filtered and isolated with pulse-height discrimination. Such a spectrum including several orders of the Cu-Lα (13.3 A/930 eV) is illustrated in Fig. 19.

To complete an absolute calibration of this spectrograph, it is necessary to include the response of the detector that is utilized. For many applications, an appropriate photographic film is used to time integrate the pulsed spectrum. We calibrate the film material by taking a series of known exposures with the film along the detection circle under the identical conditions with which a corresponding calibrated proportional counter scan has been made (as shown in Fig. 19). The exposed films are microdensitometered with a slit width that is comparable to that on the proportional counter and small as compared to that of the width of the diffraction lines. The measured densities are correlated with the measured photons/microns^2 exposures for the precisely known wavelength for the spectral line. The calibration of the RAR 2497 film by this procedure is described elsewhere in these Proceedings.

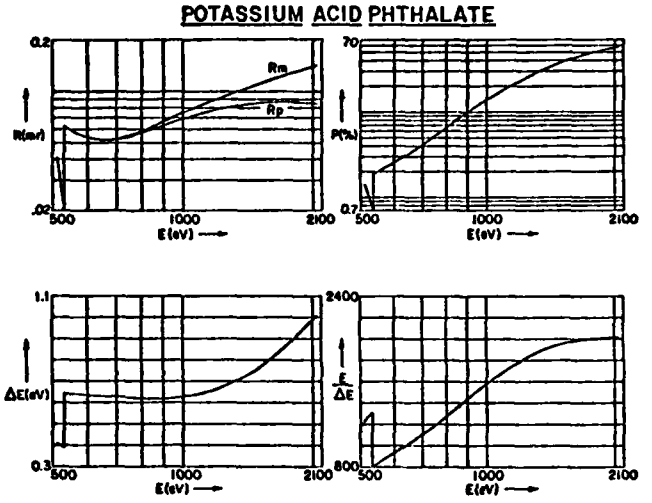


Figure 18

For many pulsed x-ray sources there may be high energy components that diffract effectively in the higher orders and make more difficult a quantitative spectral analysis. In the design of the elliptical analyzer spectrograph as described here, we have used total reflection mirror monochromators to effect the needed high-energy cut-off. We present here in Figs. 20-24 the reflectivity curves for five practical x-ray mirror monochromators which we have calculated using the methods that have been presented in the companion paper.[10] The data presented here, along with some examples of corresponding experimental data, are for mirror surfaces of beryllium, carbon, fused quartz, nickel and gold.

In the low energy diagnostics of essentially point sources (as laser-produced from microballoon sources), it is suggested here that each wavelength component will be presented in either θ or β coordinates as essentially a Lorentzian spectral component of FWHM equal to ω or φ, respectively. If the emission line has a distribution of wavelengths because of Doppler and/or Stark broadening, the measured spectral line profile is then a convolution of these and the analyzer broadening functions. Because Doppler broadening is essentially Gaussian and Stark broadening is essentially Lorentzian, a simple resolution enhancement procedure may be possible using that described above and in Ref. 1. The Voigt function fitting may need to be limited to the wings of the spectral lines if, for example, self-absorption effects have reduced the central part of the

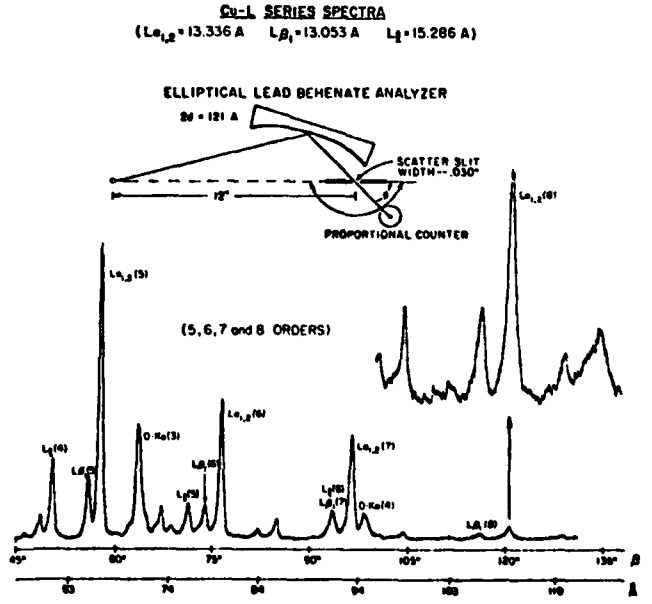


Figure 19

REFLECTIVITY OF BERYLLIUM MIRROR
(ρ = 1.85 gm/cm^3)

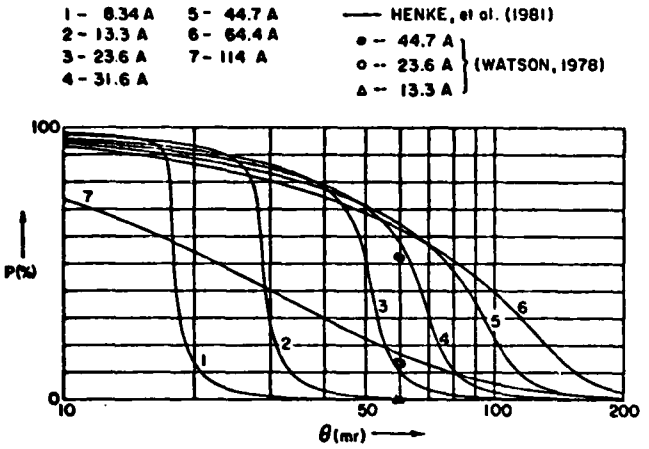


Figure 20

REFLECTIVITY OF NICKEL MIRROR
(ρ = 8.90 gm/cm^3)

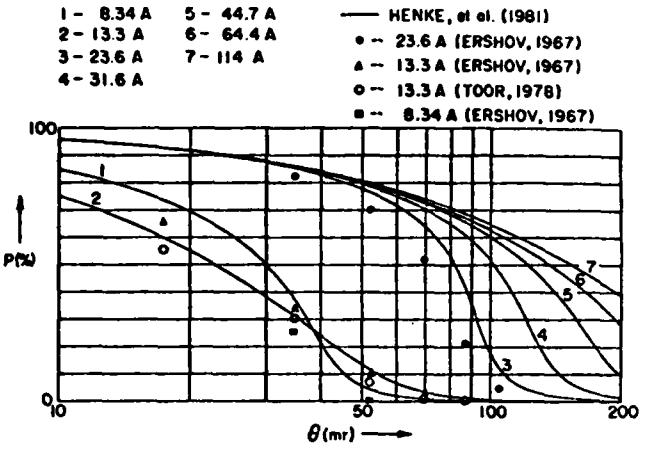


Figure 23

REFLECTIVITY OF CARBON MIRROR
(ρ = 1.54 gm/cm^3)

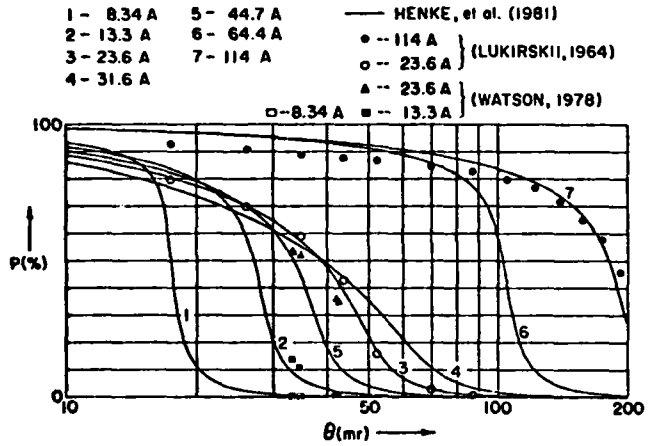


Figure 21

REFLECTIVITY OF GOLD MIRROR
(ρ = 19.32 gm/cm^3)

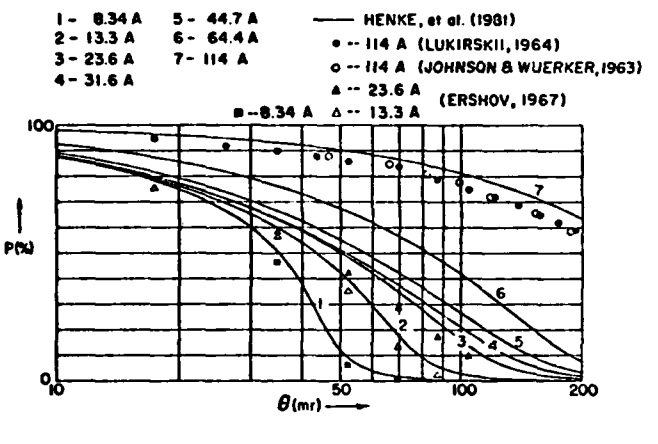


Figure 24

REFLECTIVITY OF FUSED QUARTZ MIRROR
(ρ = 2.20 gm/cm^3)

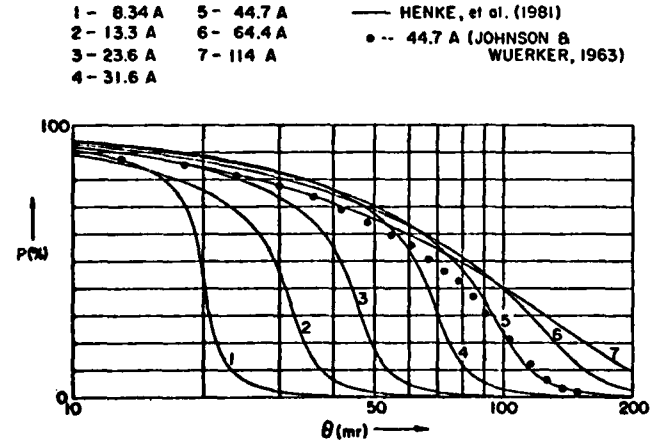


Figure 22

ONE-DIMENSIONAL IMAGING

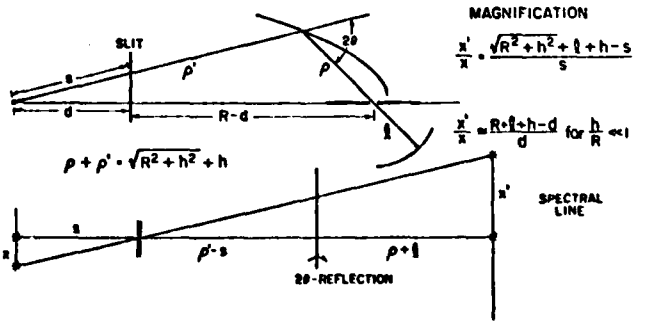


Figure 25

spectral line.

This elliptical analyzer spectrograph may be effectively applied to extended sources in order to obtain spatially resolved spectral information. In this application, the exit slit of the spectrograph becomes a limiting aperture which accepts radiation only from a linear region of the source perpendicular to the Bragg reflection plane and through the source focal point. If a vertical slit of sufficiently small width is positioned between the source focal point and the analyzer (for example at the total reflection monochromator) imaging along this linear source region occurs at nearly constant magnification along the length of the spectral line (see Fig. 25). Alternatively, this one-dimensional imaging can be obtained with larger instrument aperture by replacing the flat monochromator mirror and limiting slit by a cylindrical mirror of such curvature as to focus the radiation from a point along the accepted line source region to a corresponding point along the spectral line.

In summary, the elliptical spectrograph has three distinct advantages over the convex or flat crystal instruments for presenting an instantaneous spectrum of pulsed x-ray source. These result from the collecting and focussing into a line image within an exit aperture of radiation from a point or line source, and are: (1) the effective aperture for a given wavelength can be appreciably larger; (2) the detector circle is shielded from the total analyzer area by the exit slit acting as a scatter aperture, thus allowing a considerable reduction in background resulting from diffuse and fluorescent scatter; and (3) the sharp line image within the exit aperture allows a precise definition of the detection geometry (for example, for a film circle for a slit window of a streak camera), making possible a straightforward and accurate absolute calibration.

Finally, it should be emphasized here that for optimized low energy x-ray spectroscopy it is important to choose the 2d-values of the analyzers that are comparable to the wavelengths to be measured in order to place the desired spectral bands at the largest possible Bragg angles. At these large angles, the relative effects upon spectral resolution resulting from crystal and source size broadening are minimized because of the higher dispersion. Equally important for the low energy spectroscopy is that only at the larger angles will the Bragg reflection reflectivity of the analyzer be large as compared to its specular reflectivity. At the smaller angles, below about 20° in Bragg angle, the specular reflection tail for the longer wavelengths can represent an appreciable background at the diffraction line. It is for this reason that in the elliptical spectrograph design described here, the spectral bands to be measured are placed at β-angles from 45° to 135°.

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APPENDIX: THE ATOMIC SCATTERING FACTOR, $f_1 + if_2$, FOR 94 ELEMENTS AND FOR THE 100 TO 2000 eV PHOTON ENERGY REGION*

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In a recent work,[1] a "state of the art" evaluation and fitting of the best available experimental and theoretical photoabsorption cross sections has been presented for the 30 to 10,000 eV region. Using the quantum dispersion relations, the atomic scattering factors were uniquely determined from the photoabsorption cross section data for the low-energy x-rays. In Ref. 1, the original data were given at fifty laboratory wavelengths along with compilation references and a description of the fitting procedures. Presented here are the f_1 and f_2 values which have been interpolated at regular intervals.

As discussed in the review papers of these Proceedings by Henke,[2,3] the f_1 and f_2 parameters may be applied to calculate the low-energy x-ray interactions--absorption, scattering, specular and Bragg reflection.

The corresponding value for the photoabsorption cross section is related to f_2 by $E\mu(E) = Kf_2$, where K for a given element is presented at the end of each f_1/f_2 table for a given element in keV-cm^2/gram units. For $E\mu(E)$ in eV-barns/atom units, K is equal to 6.987×10^7 for all atoms.

The tables are presented here at 125 values of photon energy, E(eV), and wavelength, λ(A), with logarithmically spaced intervals by truncating to the nearest electron volt the energy as given by

$$E = 100 \times 10^{(N \log 20)/124)}\ \text{eV}.$$

This expression may be used for convenient computer calculation and plotting of functions of f_1 and f_2 as indexed here by N. (f_1 and f_2 have been precisely interpolated for the truncated E values listed in these tables.) The approximate K, L and M absorption edge positions are identified within the tables.

For the shorter wavelengths and for the larger angles of scattering, the accuracy of these atomic scattering factors might be improved by the inclusion of two small correction terms for relativistics and charge distribution effects. Such corrections can become of relative importance when the magnitude of the scattering factor has been appreciably reduced by anomalous dispersion. As is discussed in Refs. 1 and 2, the modified scattering factor becomes simply $f = f_1 - \Delta f_r - \Delta f_0 + if_2$, where the relativistic correction, Δf_r, is equal to $(5/3)|E_{tot}|/mc^2$, which has been tabulated by Cromer and Liberman[4] for Z = 3 to Z = 98; and the charge distribution correction, Δf_0, is equal to $(Z - f_0)$, where f_0 is the atomic form factor which recently has been tabulated as a function of $(\sin\theta/\lambda)$ by Hubbell and Overbo.[5] (Note: θ (Hubbell) = 2θ (Henke).) For $(\sin\theta/\lambda \leq .05\ A^{-1}$, $f_0 \approx Z$, and for $(\sin\theta/\lambda) \approx 0.1\ A^{-1}$, $f_0 \approx 0.9\ Z$ for most elements. An estimate of the value for the relativistic correction, Δf_r, may be given by[1,2]

$$\Delta f_r = \frac{5}{3}\frac{|E_{tot}|}{mc^2} = 2.19 \times 10^{-6}Z^3 + 1.03 \times 10^{-4}Z^2.$$

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*The f_1/f_2 data as originally presented in the Monterey Conference Proceedings have been re-evaluated and some small improvements in the fittings have been included here in the photon energy region below about 300 eV for 26 elements as based, in part, upon newly acquired photoabsorption data.

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ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	H (1) f_1	H (1) f_2	He (2) f_1	He (2) f_2	Li (3) f_1	Li (3) f_2	Be (4) f_1	Be (4) f_2	λ(A)
0	100	1.02	2.76-02	2.14	4.94-01	2.75	2.34 00	0.45	1.67-01	124.0
1	102	1.02	2.65-02	2.14	4.80-01	2.81	2.25 00	0.23	1.63-01	121.5
2	104	1.02	2.54-02	2.14	4.65-01	2.86	2.17 00	-0.06	1.59-01	119.2
3	107	1.02	2.40-02	2.15	4.46-01	2.92	2.06 00	-0.66	1.54-01	115.9
4	110	1.02	2.26-02	2.15	4.27-01	2.97	1.99 00	-2.90 K	1.49-01	112.7
5	112	1.02	2.18-02	2.15	4.15-01	3.01	1.95 00	-2.98	4.21 00	110.7
6	115	1.02	2.06-02	2.15	3.99-01	3.05	1.89 00	-0.41	4.09 00	107.8
7	118	1.02	1.95-02	2.15	3.83-01	3.08	1.83 00	0.43	3.98 00	105.1
8	121	1.02	1.85-02	2.15	3.69-01	3.12	1.76 00	0.96	3.87 00	102.5
9	124	1.02	1.76-02	2.14	3.55-01	3.15	1.70 00	1.33	3.77 00	100.0
10	127	1.02	1.67-02	2.14	3.42-01	3.17	1.65 00	1.64	3.67 00	97.6
11	130	1.02	1.59-02	2.14	3.30-01	3.20	1.60 00	1.90	3.58 00	95.4
12	133	1.02	1.52-02	2.14	3.18-01	3.22	1.55 00	2.12	3.49 00	93.2
13	136	1.02	1.45-02	2.14	3.07-01	3.24	1.49 00	2.29	3.40 00	91.2
14	140	1.01	1.36-02	2.14	2.93-01	3.25	1.43 00	2.51	3.29 00	88.6
15	143	1.01	1.30-02	2.14	2.83-01	3.27	1.38 00	2.65	3.21 00	86.7
16	147	1.01	1.22-02	2.14	2.71-01	3.28	1.32 00	2.82	3.11 00	84.3
17	150	1.01	1.17-02	2.14	2.62-01	3.29	1.29 00	2.93	3.05 00	82.7
18	154	1.01	1.11-02	2.13	2.51-01	3.30	1.24 00	3.07	2.96 00	80.5
19	158	1.01	1.05-02	2.13	2.41-01	3.31	1.19 00	3.21	2.86 00	78.5
20	162	1.01	9.94-03	2.13	2.31-01	3.31	1.15 00	3.33	2.77 00	76.5
21	166	1.01	9.43-03	2.13	2.21-01	3.32	1.11 00	3.44	2.69 00	74.7
22	170	1.01	8.95-03	2.13	2.13-01	3.32	1.07 00	3.53	2.61 00	72.9
23	174	1.01	8.51-03	2.12	2.04-01	3.32	1.03 00	3.61	2.53 00	71.3
24	178	1.01	8.09-03	2.12	1.97-01	3.33	9.97-01	3.68	2.46 00	69.7
25	182	1.01	7.71-03	2.12	1.89-01	3.33	9.65-01	3.75	2.40 00	68.1
26	187	1.01	7.26-03	2.12	1.81-01	3.33	9.22-01	3.83	2.30 00	66.3
27	191	1.01	6.93-03	2.12	1.74-01	3.33	8.88-01	3.88	2.22 00	64.9
28	196	1.01	6.55-03	2.11	1.66-01	3.33	8.51-01	3.95	2.15 00	63.3
29	201	1.01	6.20-03	2.11	1.59-01	3.33	8.18-01	4.00	2.08 00	61.7
30	206	1.01	5.87-03	2.11	1.52-01	3.32	7.87-01	4.04	2.02 00	60.2
31	211	1.01	5.57-03	2.11	1.46-01	3.32	7.57-01	4.08	1.96 00	58.8
32	216	1.01	5.29-03	2.10	1.40-01	3.32	7.28-01	4.12	1.89 00	57.4
33	221	1.01	5.03-03	2.10	1.34-01	3.32	6.99-01	4.15	1.83 00	56.1
34	227	1.01	4.74-03	2.10	1.28-01	3.31	6.67-01	4.18	1.76 00	54.6
35	232	1.01	4.52-03	2.10	1.23-01	3.31	6.42-01	4.20	1.70 00	53.4
36	238	1.01	4.27-03	2.09	1.17-01	3.31	6.14-01	4.23	1.64 00	52.1
37	244	1.01	4.05-03	2.09	1.12-01	3.30	5.88-01	4.25	1.58 00	50.8
38	250	1.01	3.84-03	2.09	1.07-01	3.30	5.64-01	4.27	1.52 00	49.6
39	256	1.01	3.64-03	2.09	1.02-01	3.29	5.41-01	4.28	1.47 00	48.4
40	262	1.01	3.46-03	2.09	9.80-02	3.29	5.19-01	4.30	1.42 00	47.3
41	269	1.01	3.27-03	2.08	9.33-02	3.28	4.96-01	4.31	1.36 00	46.1
42	275	1.01	3.11-03	2.08	8.93-02	3.28	4.77-01	4.32	1.32 00	45.1
43	282	1.01	2.95-03	2.08	8.48-02	3.27	4.56-01	4.33	1.27 00	44.0
44	289	1.00	2.79-03	2.08	8.05-02	3.27	4.36-01	4.34	1.22 00	42.9
45	296	1.00	2.65-03	2.07	7.66-02	3.26	4.17-01	4.34	1.17 00	41.9
46	303	1.00	2.52-03	2.07	7.30-02	3.26	3.99-01	4.35	1.13 00	40.9
47	311	1.00	2.37-03	2.07	6.91-02	3.25	3.80-01	4.35	1.08 00	39.9
48	318	1.00	2.26-03	2.07	6.60-02	3.25	3.65-01	4.36	1.05 00	39.0
49	326	1.00	2.13-03	2.07	6.27-02	3.24	3.48-01	4.36	1.00 00	38.0
50	334	1.00	2.02-03	2.06	5.96-02	3.24	3.33-01	4.36	9.67-01	37.1
51	342	1.00	1.91-03	2.06	5.67-02	3.23	3.19-01	4.36	9.30-01	36.3
52	351	1.00	1.80-03	2.06	5.37-02	3.23	3.04-01	4.36	8.92-01	35.3
53	359	1.00	1.71-03	2.06	5.13-02	3.22	2.91-01	4.36	8.61-01	34.5
54	368	1.00	1.62-03	2.06	4.87-02	3.21	2.78-01	4.36	8.27-01	33.7
55	377	1.00	1.53-03	2.06	4.63-02	3.21	2.66-01	4.35	7.96-01	32.9
56	386	1.00	1.45-03	2.05	4.41-02	3.20	2.54-01	4.35	7.66-01	32.1
57	396	1.00	1.37-03	2.05	4.17-02	3.20	2.42-01	4.35	7.34-01	31.3
58	406	1.00	1.29-03	2.05	3.95-02	3.19	2.31-01	4.34	7.02-01	30.5
59	415	1.00	1.23-03	2.05	3.77-02	3.19	2.21-01	4.34	6.75-01	29.9
60	426	1.00	1.16-03	2.05	3.56-02	3.18	2.10-01	4.34	6.44-01	29.1
61	436	1.00	1.10-03	2.05	3.39-02	3.18	2.01-01	4.33	6.17-01	28.4
62	447	1.00	1.04-03	2.04	3.21-02	3.17	1.91-01	4.33	5.90-01	27.7
63	458	1.00	9.84-04	2.04	3.05-02	3.17	1.82-01	4.32	5.65-01	27.1
64	469	1.00	9.32-04	2.04	2.90-02	3.16	1.74-01	4.32	5.41-01	26.4

N	E(eV)	H (1) Hydrogen f_1	H (1) Hydrogen f_2	He (2) Helium f_1	He (2) Helium f_2	Li (3) Lithium f_1	Li (3) Lithium f_2	Be (4) Beryllium f_1	Be (4) Beryllium f_2	λ(A)
65	480	1.00	8.84-04	2.04	2.75-02	3.16	1.66-01	4.31	5.19-01	25.83
66	492	1.00	8.36-04	2.04	2.61-02	3.15	1.58-01	4.30	4.96-01	25.20
67	504	1.00	7.91-04	2.04	2.48-02	3.15	1.51-01	4.30	4.75-01	24.60
68	516	1.00	7.50-04	2.04	2.36-02	3.14	1.44-01	4.29	4.55-01	24.03
69	529	1.00	7.08-04	2.03	2.24-02	3.14	1.37-01	4.29	4.35-01	23.44
70	542	1.00	6.70-04	2.03	2.12-02	3.14	1.30-01	4.28	4.16-01	22.87
71	555	1.00	6.35-04	2.03	2.02-02	3.13	1.24-01	4.27	3.99-01	22.34
72	569	1.00	6.00-04	2.03	1.91-02	3.13	1.18-01	4.27	3.81-01	21.79
73	583	1.00	5.68-04	2.03	1.81-02	3.12	1.12-01	4.26	3.64-01	21.27
74	597	1.00	5.38-04	2.03	1.72-02	3.12	1.07-01	4.26	3.48-01	20.77
75	612	1.00	5.08-04	2.03	1.63-02	3.12	1.02-01	4.25	3.32-01	20.26
76	627	1.00	4.81-04	2.03	1.55-02	3.11	9.71-02	4.24	3.18-01	19.77
77	642	1.00	4.55-04	2.03	1.47-02	3.11	9.24-02	4.24	3.04-01	19.31
78	658	1.00	4.30-04	2.02	1.38-02	3.11	8.75-02	4.23	2.89-01	18.84
79	674	1.00	4.06-04	2.02	1.31-02	3.10	8.29-02	4.23	2.75-01	18.39
80	690	1.00	3.85-04	2.02	1.24-02	3.10	7.93-02	4.22	2.64-01	17.97
81	707	1.00	3.64-04	2.02	1.19-02	3.10	7.58-02	4.21	2.53-01	17.54
82	725	1.00	3.43-04	2.02	1.12-02	3.09	7.19-02	4.21	2.41-01	17.10
83	742	1.00	3.25-04	2.02	1.07-02	3.09	6.86-02	4.20	2.30-01	16.71
84	760	1.00	3.07-04	2.02	1.01-02	3.09	6.52-02	4.20	2.20-01	16.31
85	779	1.00	2.90-04	2.02	9.60-03	3.08	6.20-02	4.19	2.09-01	15.92
86	798	1.00	2.74-04	2.02	9.10-03	3.08	5.89-02	4.19	2.00-01	15.54
87	818	1.00	2.59-04	2.02	8.62-03	3.08	5.60-02	4.18	1.90-01	15.16
88	838	1.00	2.45-04	2.02	8.17-03	3.07	5.32-02	4.18	1.81-01	14.79
89	858	1.00	2.32-04	2.02	7.76-03	3.07	5.07-02	4.17	1.73-01	14.45
90	879	1.00	2.19-04	2.02	7.37-03	3.07	4.82-02	4.17	1.65-01	14.10
91	901	1.00	2.07-04	2.01	6.99-03	3.07	4.58-02	4.16	1.58-01	13.76
92	923	1.00	1.96-04	2.01	6.64-03	3.06	4.35-02	4.16	1.50-01	13.43
93	945	1.00	1.85-04	2.01	6.32-03	3.06	4.14-02	4.15	1.44-01	13.12
94	968	1.00	1.75-04	2.01	6.00-03	3.06	3.94-02	4.15	1.37-01	12.81
95	992	1.00	1.66-04	2.01	5.70-03	3.06	3.74-02	4.14	1.30-01	12.50
96	1016	1.00	1.57-04	2.01	5.42-03	3.06	3.56-02	4.14	1.24-01	12.20
97	1041	1.00	1.48-04	2.01	5.13-03	3.05	3.38-02	4.13	1.18-01	11.91
98	1067	1.00	1.40-04	2.01	4.86-03	3.05	3.21-02	4.13	1.12-01	11.62
99	1093	1.00	1.32-04	2.01	4.61-03	3.05	3.05-02	4.12	1.07-01	11.34
100	1119	1.00	1.25-04	2.01	4.38-03	3.05	2.91-02	4.12	1.02-01	11.08
101	1147	1.00	1.18-04	2.01	4.15-03	3.05	2.76-02	4.12	9.69-02	10.81
102	1175	1.00	1.12-04	2.01	3.93-03	3.05	2.62-02	4.11	9.22-02	10.55
103	1204	1.00	1.06-04	2.01	3.73-03	3.04	2.49-02	4.11	8.77-02	10.30
104	1233	1.00	9.98-05	2.01	3.54-03	3.04	2.37-02	4.11	8.35-02	10.06
105	1263	1.00	9.43-05	2.01	3.36-03	3.04	2.25-02	4.10	7.95-02	9.82
106	1294	1.00	8.91-05	2.01	3.19-03	3.04	2.14-02	4.10	7.56-02	9.58
107	1326	1.00	8.41-05	2.01	3.03-03	3.04	2.03-02	4.10	7.19-02	9.35
108	1358	1.00	7.95-05	2.01	2.88-03	3.04	1.93-02	4.09	6.85-02	9.13
109	1392	1.00	7.50-05	2.01	2.73-03	3.03	1.83-02	4.09	6.51-02	8.91
110	1426	1.00	7.08-05	2.01	2.60-03	3.03	1.74-02	4.09	6.20-02	8.69
111	1460	1.00	6.70-05	2.01	2.47-03	3.03	1.65-02	4.08	5.91-02	8.49
112	1496	1.00	6.32-05	2.01	2.34-03	3.03	1.57-02	4.08	5.62-02	8.29
113	1533	1.00	5.97-05	2.01	2.21-03	3.03	1.48-02	4.08	5.34-02	8.09
114	1570	1.00	5.64-05	2.01	2.10-03	3.03	1.41-02	4.07	5.08-02	7.90
115	1609	1.00	5.32-05	2.01	1.98-03	3.03	1.34-02	4.07	4.83-02	7.71
116	1648	1.00	5.03-05	2.01	1.88-03	3.03	1.27-02	4.07	4.59-02	7.52
117	1688	1.00	4.76-05	2.01	1.78-03	3.03	1.20-02	4.07	4.37-02	7.34
118	1730	1.00	4.49-05	2.00	1.68-03	3.02	1.14-02	4.06	4.15-02	7.17
119	1772	1.00	4.24-05	2.00	1.59-03	3.02	1.08-02	4.06	3.95-02	7.00
120	1815	1.00	4.01-05	2.00	1.50-03	3.02	1.02-02	4.06	3.75-02	6.83
121	1860	1.00	3.78-05	2.00	1.41-03	3.02	9.70-03	4.06	3.56-02	6.67
122	1905	1.00	3.57-05	2.00	1.34-03	3.02	9.20-03	4.06	3.38-02	6.51
123	1952	1.00	3.37-05	2.00	1.26-03	3.02	8.71-03	4.05	3.21-02	6.35
124	2000	1.00	3.18-05	2.00	1.19-03	3.02	8.25-03	4.05	3.05-02	6.20
	$\frac{E\mu(E)}{f_2}$	41725		10507		6059.		4667.		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	1.008		4.003		6.941		9.012		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	B (5) f_1	B (5) f_2	C (6) f_1	C (6) f_2	N (7) f_1	N (7) f_2	O (8) f_1	O (8) f_2	λ(A)
0	100	2.90	3.47-01	4.08	6.66-01	5.22	1.45 00	6.13	2.50 00	124.0
1	102	2.89	3.39-01	4.08	6.52-01	5.23	1.42 00	6.16	2.43 00	121.5
2	104	2.88	3.30-01	4.08	6.39-01	5.24	1.38 00	6.19	2.38 00	119.2
3	107	2.86	3.19-01	4.08	6.21-01	5.26	1.34 00	6.22	2.29 00	115.9
4	110	2.84	3.09-01	4.07	6.03-01	5.27	1.29 00	6.25	2.22 00	112.7
5	112	2.82	3.04-01	4.07	5.92-01	5.28	1.27 00	6.27	2.17 00	110.7
6	115	2.80	2.95-01	4.07	5.75-01	5.29	1.23 00	6.30	2.10 00	107.8
7	118	2.77	2.86-01	4.07	5.59-01	5.29	1.19 00	6.32	2.03 00	105.1
8	121	2.75	2.77-01	4.06	5.44-01	5.30	1.16 00	6.34	1.97 00	102.5
9	124	2.72	2.69-01	4.06	5.30-01	5.30	1.12 00	6.35	1.91 00	100.0
10	127	2.68	2.61-01	4.05	5.17-01	5.31	1.09 00	6.37	1.85 00	97.6
11	130	2.65	2.53-01	4.05	5.04-01	5.31	1.06 00	6.39	1.80 00	95.4
12	133	2.61	2.46-01	4.04	4.91-01	5.32	1.03 00	6.41	1.75 00	93.2
13	136	2.57	2.39-01	4.03	4.78-01	5.32	1.00 00	6.41	1.70 00	91.2
14	140	2.51	2.30-01	4.02	4.62-01	5.32	9.67-01	6.43	1.64 00	88.6
15	143	2.46	2.24-01	4.01	4.51-01	5.32	9.41-01	6.43	1.59 00	86.7
16	147	2.38	2.16-01	4.00	4.37-01	5.32	9.09-01	6.45	1.54 00	84.3
17	150	2.32	2.11-01	3.99	4.27-01	5.32	8.87-01	6.45	1.50 00	82.7
18	154	2.22	2.04-01	3.97	4.14-01	5.31	8.58-01	6.46	1.45 00	80.5
19	158	2.11	1.96-01	3.95	4.02-01	5.31	8.31-01	6.46	1.40 00	78.5
20	162	1.98	1.88-01	3.94	3.90-01	5.31	8.04-01	6.47	1.36 00	76.5
21	166	1.82	1.80-01	3.92	3.78-01	5.30	7.79-01	6.47	1.31 00	74.7
22	170	1.62	1.74-01	3.90	3.66-01	5.30	7.55-01	6.47	1.27 00	72.9
23	174	1.34	1.68-01	3.87	3.55-01	5.29	7.33-01	6.47	1.23 00	71.3
24	178	1.02	1.64-01	3.85	3.45-01	5.28	7.11-01	6.47	1.20 00	69.7
25	182	0.39	1.59-01	3.82	3.35-01	5.27	6.91-01	6.47	1.16 00	68.1
26	187	-2.43 K	1.53-01	3.79	3.24-01	5.26	6.67-01	6.47	1.12 00	66.3
27	191	-0.55	4.18 00	3.76	3.15-01	5.25	6.49-01	6.47	1.08 00	64.9
28	196	1.08	4.06 00	3.71	3.05-01	5.24	6.27-01	6.46	1.04 00	63.3
29	201	1.74	3.95 00	3.67	2.95-01	5.23	6.06-01	6.46	1.01 00	61.7
30	206	2.19	3.85 00	3.62	2.85-01	5.21	5.86-01	6.45	9.75-01	60.2
31	211	2.55	3.76 00	3.57	2.75-01	5.20	5.68-01	6.45	9.45-01	58.8
32	216	2.83	3.65 00	3.51	2.66-01	5.18	5.50-01	6.44	9.14-01	57.4
33	221	3.06	3.54 00	3.44	2.57-01	5.17	5.33-01	6.43	8.84-01	56.1
34	227	3.31	3.42 00	3.35	2.47-01	5.15	5.14-01	6.42	8.50-01	54.6
35	232	3.49	3.32 00	3.26	2.40-01	5.13	4.98-01	6.41	8.24-01	53.4
36	238	3.70	3.21 00	3.15	2.31-01	5.10	4.81-01	6.40	7.94-01	52.1
37	244	3.88	3.11 00	3.01	2.23-01	5.08	4.65-01	6.39	7.66-01	50.8
38	250	4.04	3.01 00	2.84	2.15-01	5.05	4.50-01	6.37	7.39-01	49.6
39	256	4.18	2.92 00	2.63	2.08-01	5.02	4.35-01	6.36	7.14-01	48.4
40	262	4.29	2.83 00	2.35	2.01-01	4.99	4.21-01	6.35	6.90-01	47.3
41	269	4.41	2.74 00	1.92	1.94-01	4.96	4.06-01	6.33	6.64-01	46.1
42	275	4.51	2.66 00	1.22	1.88-01	4.92	3.94-01	6.32	6.43-01	45.1
43	282	4.60	2.57 00	-1.56 K	1.81-01	4.88	3.80-01	6.30	6.20-01	44.0
44	289	4.68	2.48 00	-0.12	4.48 00	4.83	3.67-01	6.28	5.97-01	42.9
45	296	4.76	2.39 00	2.17	4.33 00	4.78	3.55-01	6.26	5.76-01	41.9
46	303	4.82	2.32 00	2.88	4.18 00	4.72	3.43-01	6.24	5.56-01	40.9
47	311	4.88	2.23 00	3.47	4.02 00	4.65	3.31-01	6.22	5.35-01	39.9
48	318	4.93	2.16 00	3.83	3.89 00	4.58	3.20-01	6.19	5.17-01	39.0
49	326	4.98	2.08 00	4.16	3.75 00	4.49	3.09-01	6.16	4.98-01	38.0
50	334	5.03	2.01 00	4.41	3.62 00	4.39	2.99-01	6.13	4.81-01	37.1
51	342	5.07	1.94 00	4.63	3.50 00	4.28	2.89-01	6.10	4.64-01	36.3
52	351	5.11	1.87 00	4.84	3.37 00	4.11	2.78-01	6.06	4.46-01	35.3
53	359	5.15	1.81 00	4.99	3.26 00	3.93	2.69-01	6.03	4.31-01	34.5
54	368	5.18	1.75 00	5.14	3.14 00	3.69	2.60-01	5.98	4.15-01	33.7
55	377	5.21	1.69 00	5.28	3.03 00	3.34	2.51-01	5.94	4.01-01	32.9
56	386	5.23	1.63 00	5.39	2.93 00	2.69	2.42-01	5.89	3.87-01	32.1
57	396	5.25	1.57 00	5.50	2.82 00	1.22 K	2.34-01	5.84	3.72-01	31.3
58	406	5.27	1.51 00	5.59	2.72 00	0.96	3.96 00	5.77	3.57-01	30.5
59	415	5.29	1.46 00	5.66	2.63 00	3.10	3.90 00	5.70	3.45-01	29.9
60	426	5.30	1.40 00	5.74	2.53 00	3.85	3.84 00	5.62	3.31-01	29.1
61	436	5.31	1.35 00	5.81	2.45 00	4.34	3.78 00	5.53	3.20-01	28.4
62	447	5.33	1.30 00	5.87	2.36 00	4.76	3.72 00	5.42	3.08-01	27.7
63	458	5.33	1.25 00	5.93	2.28 00	5.10	3.67 00	5.30	2.96-01	27.1
64	469	5.34	1.20 00	5.98	2.20 00	5.37	3.55 00	5.13	2.85-01	26.4

		B (5) Boron		C (6) Carbon		N (7) Nitrogen		O (8) Oxygen		
N	E(eV)	f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	λ(A)
65	480	5.35	1.16 00	6.02	2.12 00	5.61	3.43 00	4.94	2.75-01	25.83
66	492	5.35	1.11 00	6.06	2.04 00	5.82	3.32 00	4.67	2.65-01	25.20
67	504	5.35	1.07 00	6.10	1.97 00	5.99	3.20 00	4.29	2.55-01	24.60
68	516	5.36	1.03 00	6.13	1.90 00	6.14	3.10 00	3.62	2.46-01	24.03
69	529	5.36	9.87-01	6.17	1.83 00	6.27	2.99 00	1.37 K	2.37-01	23.44
70	542	5.36	9.47-01	6.20	1.77 00	6.38	2.89 00	3.23	4.43 00	22.87
71	555	5.36	9.09-01	6.22	1.70 00	6.48	2.80 00	4.33	4.28 00	22.34
72	569	5.36	8.73-01	6.25	1.64 00	6.58	2.70 00	5.03	4.12 00	21.79
73	583	5.36	8.38-01	6.27	1.57 00	6.67	2.60 00	5.54	3.98 00	21.27
74	597	5.36	8.05-01	6.28	1.52 00	6.74	2.51 00	5.91	3.85 00	20.77
75	612	5.35	7.71-01	6.30	1.46 00	6.82	2.42 00	6.25	3.72 00	20.26
76	627	5.35	7.40-01	6.31	1.40 00	6.89	2.34 00	6.53	3.60 00	19.77
77	642	5.35	7.09-01	6.32	1.35 00	6.95	2.25 00	6.75	3.47 00	19.31
78	658	5.34	6.76-01	6.33	1.29 00	7.00	2.16 00	6.93	3.34 00	18.84
79	674	5.34	6.45-01	6.34	1.24 00	7.05	2.08 00	7.09	3.21 00	18.39
80	690	5.33	6.21-01	6.34	1.20 00	7.09	2.01 00	7.23	3.11 00	17.97
81	707	5.33	5.97-01	6.35	1.16 00	7.13	1.95 00	7.35	3.02 00	17.54
82	725	5.32	5.71-01	6.36	1.11 00	7.16	1.87 00	7.46	2.90 00	17.10
83	742	5.32	5.48-01	6.36	1.07 00	7.19	1.80 00	7.56	2.80 00	16.71
84	760	5.31	5.24-01	6.37	1.02 00	7.22	1.74 00	7.65	2.71 00	16.31
85	779	5.31	5.02-01	6.37	9.80-01	7.24	1.67 00	7.73	2.61 00	15.92
86	798	5.30	4.80-01	6.37	9.40-01	7.26	1.60 00	7.81	2.51 00	15.54
87	818	5.30	4.59-01	6.37	9.01-01	7.28	1.54 00	7.88	2.41 00	15.16
88	838	5.29	4.39-01	6.37	8.64-01	7.30	1.48 00	7.94	2.31 00	14.79
89	858	5.29	4.20-01	6.37	8.29-01	7.32	1.42 00	8.00	2.23 00	14.45
90	879	5.28	4.01-01	6.36	7.95-01	7.33	1.36 00	8.05	2.15 00	14.10
91	901	5.27	3.83-01	6.36	7.61-01	7.34	1.31 00	8.09	2.07 00	13.76
92	923	5.27	3.66-01	6.36	7.30-01	7.35	1.26 00	8.13	2.00 00	13.43
93	945	5.26	3.50-01	6.35	7.00-01	7.36	1.21 00	8.16	1.93 00	13.12
94	968	5.25	3.35-01	6.35	6.71-01	7.36	1.16 00	8.19	1.85 00	12.81
95	992	5.25	3.20-01	6.34	6.42-01	7.36	1.12 00	8.22	1.78 00	12.50
96	1016	5.24	3.06-01	6.34	6.16-01	7.37	1.07 00	8.25	1.71 00	12.20
97	1041	5.24	2.92-01	6.33	5.90-01	7.37	1.03 00	8.27	1.64 00	11.91
98	1067	5.23	2.79-01	6.33	5.64-01	7.37	9.86-01	8.29	1.58 00	11.62
99	1093	5.22	2.66-01	6.32	5.40-01	7.37	9.46-01	8.31	1.52 00	11.34
100	1119	5.22	2.54-01	6.32	5.17-01	7.37	9.09-01	8.32	1.46 00	11.08
101	1147	5.21	2.42-01	6.31	4.94-01	7.37	8.71-01	8.33	1.40 00	10.81
102	1175	5.21	2.31-01	6.31	4.73-01	7.37	8.35-01	8.35	1.34 00	10.55
103	1204	5.20	2.21-01	6.30	4.52-01	7.37	8.01-01	8.36	1.29 00	10.30
104	1233	5.20	2.11-01	6.29	4.33-01	7.36	7.68-01	8.36	1.24 00	10.06
105	1263	5.19	2.01-01	6.29	4.14-01	7.36	7.37-01	8.37	1.19 00	9.82
106	1294	5.18	1.92-01	6.28	3.96-01	7.36	7.05-01	8.37	1.14 00	9.58
107	1326	5.18	1.83-01	6.28	3.78-01	7.35	6.74-01	8.38	1.10 00	9.35
108	1358	5.17	1.75-01	6.27	3.62-01	7.35	6.46-01	8.38	1.05 00	9.13
109	1392	5.17	1.66-01	6.26	3.45-01	7.34	6.17-01	8.38	1.01 00	8.91
110	1426	5.16	1.59-01	6.26	3.30-01	7.34	5.91-01	8.38	9.69-01	8.69
111	1460	5.16	1.52-01	6.25	3.16-01	7.33	5.66-01	8.38	9.31-01	8.49
112	1496	5.15	1.44-01	6.24	3.01-01	7.33	5.42-01	8.38	8.93-01	8.29
113	1533	5.15	1.38-01	6.24	2.88-01	7.32	5.18-01	8.38	8.56-01	8.09
114	1570	5.14	1.31-01	6.23	2.75-01	7.31	4.96-01	8.37	8.20-01	7.90
115	1609	5.14	1.25-01	6.22	2.62-01	7.31	4.74-01	8.37	7.86-01	7.71
116	1648	5.14	1.19-01	6.22	2.51-01	7.30	4.53-01	8.37	7.53-01	7.52
117	1688	5.13	1.14-01	6.21	2.39-01	7.30	4.34-01	8.36	7.22-01	7.34
118	1730	5.13	1.08-01	6.21	2.28-01	7.29	4.14-01	8.36	6.91-01	7.17
119	1772	5.12	1.03-01	6.20	2.18-01	7.28	3.96-01	8.36	6.62-01	7.00
120	1815	5.12	9.82-02	6.19	2.08-01	7.27	3.79-01	8.35	6.34-01	6.83
121	1860	5.11	9.34-02	6.19	1.99-01	7.27	3.62-01	8.34	6.07-01	6.67
122	1905	5.11	8.90-02	6.18	1.90-01	7.26	3.46-01	8.34	5.82-01	6.51
123	1952	5.11	8.47-02	6.18	1.81-01	7.26	3.30-01	8.33	5.57-01	6.35
124	2000	5.10	8.07-02	6.17	1.73-01	7.25	3.15-01	8.33	5.33-01	6.20
	$\frac{\Sigma\mu(E)}{\rho_2}$	3890.		3502.		3003.		2629.		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	10.81		12.01		14.01		16.00		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	F (9) f_1	F (9) f_2	Ne (10) f_1	Ne (10) f_2	Na (11) f_1	Na (11) f_2	Mg (12) f_1	Mg (12) f_2	λ(A)
0	100	6.71	3.95 00	6.26	5.47 00	6.23	7.70 00	3.73	7.54 00	124.0
1	102	6.78	3.86 00	6.39	5.41 00	6.42	7.58 00	4.11	7.58 00	121.5
2	104	6.84	3.78 00	6.51	5.34 00	6.59	7.46 00	4.42	7.66 00	119.2
3	107	6.91	3.67 00	6.67	5.25 00	6.83	7.29 00	4.84	7.87 00	115.9
4	110	6.98	3.56 00	6.83	5.15 00	7.04	7.14 00	5.21	8.04 00	112.7
5	112	7.02	3.49 00	6.93	5.09 00	7.16	7.03 00	5.44	8.15 00	110.7
6	115	7.08	3.39 00	7.07	4.98 00	7.34	6.89 00	5.76	8.28 00	107.8
7	118	7.13	3.29 00	7.20	4.87 00	7.51	6.75 00	6.07	8.19 00	105.1
8	121	7.18	3.21 00	7.31	4.77 00	7.67	6.61 00	6.36	8.10 00	102.5
9	124	7.22	3.12 00	7.41	4.67 00	7.81	6.48 00	6.64	7.90 00	100.0
10	127	7.26	3.04 00	7.51	4.57 00	7.96	6.36 00	6.92	7.61 00	97.6
11	130	7.30	2.96 00	7.60	4.47 00	8.10	6.24 00	7.21	7.34 00	95.4
12	133	7.34	2.88 00	7.69	4.38 00	8.23	6.10 00	7.50	7.32 00	93.2
13	136	7.37	2.81 00	7.76	4.28 00	8.34	5.97 00	7.72	7.30 00	91.2
14	140	7.41	2.71 00	7.86	4.16 00	8.48	5.81 00	7.99	7.26 00	88.6
15	143	7.43	2.64 00	7.92	4.07 00	8.58	5.69 00	8.18	7.23 00	86.7
16	147	7.46	2.55 00	7.99	3.96 00	8.69	5.53 00	8.40	7.18 00	84.3
17	150	7.48	2.49 00	8.05	3.89 00	8.77	5.43 00	8.56	7.13 00	82.7
18	154	7.50	2.41 00	8.12	3.78 00	8.87	5.29 00	8.75	7.06 00	80.5
19	158	7.53	2.34 00	8.19	3.68 00	8.97	5.16 00	8.93	7.00 00	78.5
20	162	7.54	2.27 00	8.24	3.58 00	9.06	5.02 00	9.11	6.92 00	76.5
21	166	7.56	2.20 00	8.29	3.48 00	9.15	4.89 00	9.27	6.81 00	74.7
22	170	7.57	2.13 00	8.34	3.39 00	9.22	4.77 00	9.41	6.71 00	72.9
23	174	7.58	2.07 00	8.39	3.31 00	9.28	4.65 00	9.53	6.61 00	71.3
24	178	7.59	2.01 00	8.43	3.22 00	9.35	4.54 00	9.65	6.49 00	69.7
25	182	7.60	1.95 00	8.46	3.14 00	9.40	4.43 00	9.76	6.35 00	68.1
26	187	7.61	1.88 00	8.50	3.04 00	9.48	4.30 00	9.89	6.18 00	66.3
27	191	7.62	1.83 00	8.53	2.96 00	9.54	4.20 00	9.99	6.05 00	64.9
28	196	7.62	1.77 00	8.57	2.88 00	9.60	4.06 00	10.10	5.87 00	63.3
29	201	7.63	1.71 00	8.60	2.79 00	9.65	3.93 00	10.19	5.69 00	61.7
30	206	7.63	1.66 00	8.63	2.71 00	9.69	3.81 00	10.28	5.52 00	60.2
31	211	7.63	1.60 00	8.66	2.64 00	9.73	3.69 00	10.37	5.34 00	58.8
32	216	7.63	1.55 00	8.69	2.55 00	9.76	3.58 00	10.44	5.16 00	57.4
33	221	7.63	1.50 00	8.71	2.47 00	9.79	3.48 00	10.51	4.98 00	56.1
34	227	7.63	1.45 00	8.73	2.38 00	9.82	3.36 00	10.58	4.81 00	54.6
35	232	7.63	1.41 00	8.74	2.31 00	9.84	3.27 00	10.63	4.68 00	53.4
36	238	7.62	1.36 00	8.75	2.23 00	9.87	3.16 00	10.69	4.55 00	52.1
37	244	7.62	1.31 00	8.76	2.15 00	9.89	3.06 00	10.74	4.41 00	50.8
38	250	7.61	1.27 00	8.77	2.08 00	9.91	2.96 00	10.79	4.29 00	49.6
39	256	7.61	1.22 00	8.78	2.01 00	9.92	2.87 00	10.83	4.17 00	48.4
40	262	7.60	1.19 00	8.78	1.95 00	9.93	2.78 00	10.87	4.06 00	47.3
41	269	7.59	1.14 00	8.78	1.88 00	9.95	2.68 00	10.90	3.95 00	46.1
42	275	7.58	1.11 00	8.79	1.82 00	9.95	2.60 00	10.93	3.86 00	45.1
43	282	7.57	1.07 00	8.79	1.75 00	9.96	2.52 00	10.96	3.76 00	44.0
44	289	7.56	1.03 00	8.79	1.69 00	9.97	2.43 00	10.99	3.67 00	42.9
45	296	7.55	9.95-01	8.79	1.63 00	9.97	2.35 00	11.01	3.58 00	41.9
46	303	7.54	9.62-01	8.78	1.57 00	9.97	2.28 00	11.03	3.50 00	40.9
47	311	7.52	9.25-01	8.77	1.51 00	9.97	2.20 00	11.05	3.39 00	39.9
48	318	7.51	8.96-01	8.77	1.46 00	9.98	2.13 00	11.07	3.29 00	39.0
49	326	7.49	8.63-01	8.76	1.40 00	9.97	2.06 00	11.08	3.19 00	38.0
50	334	7.48	8.33-01	8.75	1.35 00	9.97	1.99 00	11.09	3.08 00	37.1
51	342	7.46	8.04-01	8.74	1.31 00	9.97	1.92 00	11.10	2.99 00	36.3
52	351	7.44	7.73-01	8.72	1.25 00	9.96	1.85 00	11.10	2.89 00	35.3
53	359	7.42	7.48-01	8.71	1.21 00	9.96	1.79 00	11.11	2.80 00	34.5
54	368	7.40	7.21-01	8.70	1.17 00	9.95	1.73 00	11.11	2.71 00	33.7
55	377	7.38	6.95-01	8.68	1.12 00	9.94	1.67 00	11.11	2.63 00	32.9
56	386	7.35	6.71-01	8.67	1.08 00	9.93	1.61 00	11.11	2.55 00	32.1
57	396	7.33	6.46-01	8.65	1.04 00	9.92	1.55 00	11.11	2.45 00	31.3
58	406	7.30	6.22-01	8.64	9.97-01	9.91	1.49 00	11.10	2.35 00	30.5
59	415	7.27	6.02-01	8.62	9.61-01	9.90	1.45 00	11.10	2.28 00	29.9
60	426	7.24	5.79-01	8.60	9.21-01	9.88	1.39 00	11.09	2.19 00	29.1
61	436	7.21	5.59-01	8.58	8.86-01	9.87	1.34 00	11.08	2.11 00	28.4
62	447	7.17	5.38-01	8.55	8.50-01	9.85	1.29 00	11.07	2.03 00	27.7
63	458	7.14	5.18-01	8.53	8.16-01	9.84	1.25 00	11.07	1.96 00	27.1
64	469	7.10	5.00-01	8.50	7.85-01	9.82	1.20 00	11.05	1.88 00	26.4

N	E(eV)	F (9) Fluorine f_1	F (9) Fluorine f_2	Ne (10) Neon f_1	Ne (10) Neon f_2	Na (11) Sodium f_1	Na (11) Sodium f_2	Mg (12) Magnesium f_1	Mg (12) Magnesium f_2	λ(A)
65	480	7.05	4.83-01	8.48	7.55-01	9.81	1.16 00	11.04	1.81 00	25.83
66	492	7.00	4.65-01	8.45	7.24-01	9.79	1.12 00	11.03	1.74 00	25.20
67	504	6.95	4.48-01	8.42	6.96-01	9.77	1.08 00	11.02	1.68 00	24.60
68	516	6.89	4.32-01	8.39	6.69-01	9.75	1.04 00	11.00	1.61 00	24.03
69	529	6.82	4.15-01	8.35	6.42-01	9.73	9.99-01	10.99	1.55 00	23.44
70	542	6.75	4.00-01	8.32	6.16-01	9.71	9.62-01	10.97	1.49 00	22.87
71	555	6.66	3.85-01	8.28	5.93-01	9.68	9.27-01	10.96	1.44 00	22.34
72	569	6.56	3.71-01	8.24	5.68-01	9.66	8.91-01	10.94	1.38 00	21.79
73	583	6.44	3.57-01	8.20	5.46-01	9.63	8.58-01	10.92	1.32 00	21.27
74	597	6.30	3.44-01	8.15	5.25-01	9.61	8.26-01	10.90	1.27 00	20.77
75	612	6.12	3.31-01	8.10	5.04-01	9.58	7.98-01	10.88	1.22 00	20.26
76	627	5.89	3.18-01	8.04	4.84-01	9.55	7.72-01	10.86	1.17 00	19.77
77	642	5.58	3.06-01	7.99	4.65-01	9.52	7.44-01	10.83	1.13 00	19.31
78	658	5.00	2.95-01	7.92	4.45-01	9.49	7.11-01	10.81	1.08 00	18.84
79	674	4.17	2.84-01	7.84	4.26-01	9.45	6.80-01	10.79	1.03 00	18.39
80	690	2.36 K	4.22 00	7.76	4.11-01	9.42	6.55-01	10.76	9.94-01	17.97
81	707	5.01	4.09 00	7.66	3.97-01	9.38	6.31-01	10.74	9.58-01	17.54
82	725	5.81	3.98 00	7.54	3.81-01	9.34	6.05-01	10.71	9.17-01	17.10
83	742	6.38	3.93 00	7.42	3.67-01	9.29	5.81-01	10.68	8.81-01	16.71
84	760	6.82	3.84 00	7.26	3.53-01	9.24	5.58-01	10.65	8.46-01	16.31
85	779	7.21	3.71 00	7.06	3.40-01	9.19	5.35-01	10.62	8.10-01	15.92
86	798	7.50	3.57 00	6.78	3.26-01	9.13	5.13-01	10.59	7.77-01	15.54
87	818	7.73	3.43 00	6.40	3.13-01	9.06	4.91-01	10.55	7.44-01	15.16
88	838	7.92	3.30 00	5.64	3.00-01	8.99	4.71-01	10.51	7.14-01	14.79
89	858	8.08	3.19 00	3.62 K	2.88-01	8.91	4.52-01	10.47	6.85-01	14.45
90	879	8.22	3.08 00	4.07	4.45 00	8.81	4.34-01	10.43	6.57-01	14.10
91	901	8.35	2.98 00	6.42	4.29 00	8.70	4.16-01	10.39	6.29-01	13.76
92	923	8.46	2.88 00	7.17	4.14 00	8.57	3.99-01	10.34	6.04-01	13.43
93	945	8.57	2.78 00	7.68	4.00 00	8.42	3.82-01	10.28	5.80-01	13.12
94	968	8.66	2.69 00	8.09	3.86 00	8.21	3.65-01	10.22	5.56-01	12.81
95	992	8.75	2.59 00	8.40	3.73 00	7.93	3.49-01	10.16	5.33-01	12.50
96	1016	8.83	2.50 00	8.67	3.60 00	7.57	3.34-01	10.09	5.11-01	12.20
97	1041	8.89	2.41 00	8.90	3.46 00	6.91	3.19-01	10.01	4.90-01	11.91
98	1067	8.95	2.32 00	9.08	3.33 00	4.21 K	3.05-01	9.91	4.69-01	11.62
99	1093	9.01	2.23 00	9.24	3.20 00	5.55	4.42 00	9.80	4.50-01	11.34
100	1119	9.05	2.15 00	9.38	3.09 00	7.82	4.26 00	9.68	4.32-01	11.08
101	1147	9.10	2.07 00	9.51	2.97 00	8.46	4.10 00	9.52	4.14-01	10.81
102	1175	9.14	2.00 00	9.62	2.86 00	8.94	3.95 00	9.32	3.97-01	10.55
103	1204	9.17	1.92 00	9.71	2.75 00	9.30	3.80 00	9.04	3.80-01	10.30
104	1233	9.21	1.85 00	9.79	2.65 00	9.57	3.66 00	8.69	3.65-01	10.06
105	1263	9.23	1.78 00	9.87	2.55 00	9.80	3.52 00	8.02	3.50-01	9.82
106	1294	9.26	1.71 00	9.94	2.45 00	10.00	3.39 00	5.42 K	3.35-01	9.58
107	1326	9.28	1.64 00	10.00	2.36 00	10.17	3.26 00	6.97	4.36 00	9.35
108	1358	9.30	1.58 00	10.05	2.27 00	10.31	3.14 00	8.89	4.21 00	9.13
109	1392	9.32	1.52 00	10.10	2.18 00	10.45	3.02 00	9.52	4.05 00	8.91
110	1426	9.33	1.46 00	10.14	2.10 00	10.56	2.91 00	10.01	3.91 00	8.69
111	1460	9.35	1.40 00	10.18	2.02 00	10.66	2.81 00	10.35	3.78 00	8.49
112	1496	9.36	1.35 00	10.22	1.94 00	10.75	2.70 00	10.64	3.65 00	8.29
113	1533	9.36	1.29 00	10.25	1.86 00	10.83	2.60 00	10.86	3.52 00	8.09
114	1570	9.37	1.24 00	10.27	1.79 00	10.90	2.50 00	11.05	3.40 00	7.90
115	1609	9.38	1.19 00	10.30	1.72 00	10.97	2.41 00	11.22	3.28 00	7.71
116	1648	9.38	1.14 00	10.32	1.65 00	11.03	2.32 00	11.37	3.16 00	7.52
117	1688	9.39	1.09 00	10.33	1.59 00	11.08	2.23 00	11.49	3.05 00	7.34
118	1730	9.39	1.05 00	10.35	1.52 00	11.13	2.15 00	11.60	2.95 00	7.17
119	1772	9.39	1.01 00	10.36	1.46 00	11.17	2.07 00	11.70	2.84 00	7.00
120	1815	9.39	9.64-01	10.37	1.40 00	11.21	1.99 00	11.79	2.73 00	6.83
121	1860	9.39	9.23-01	10.38	1.35 00	11.24	1.91 00	11.87	2.63 00	6.67
122	1905	9.39	8.85-01	10.39	1.29 00	11.26	1.83 00	11.94	2.53 00	6.51
123	1952	9.39	8.48-01	10.39	1.24 00	11.29	1.76 00	12.00	2.43 00	6.35
124	2000	9.38	8.13-01	10.40	1.19 00	11.31	1.69 00	12.06	2.34 00	6.20
	$\frac{E\mu(E)}{I_2}$	2214.		2084.		1829.		1730.		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	19.00		20.18		22.99		24.31		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Al (13) f_1	Al (13) f_2	Si (14) f_1	Si (14) f_2	P (15) f_1	P (15) f_2	S (16) f_1	S (16) f_2	λ(Å)
0	100	2.65	7.60 00	-9.22 L	4.47-01	2.93	7.51-01	4.76	1.11 00	124.0
1	102	2.36	6.51 00	-7.27	7.92 00	2.80	7.44-01	4.72	1.10 00	121.5
2	104	2.04	6.36 00	-4.13	8.03 00	2.65	7.37-01	4.67	1.08 00	119.2
3	107	1.48	7.02 00	-2.33	8.21 00	2.41	7.27-01	4.60	1.07 00	115.9
4	110	1.71	7.77 00	-1.39	8.38 00	2.11	7.19-01	4.51	1.05 00	112.7
5	112	2.01	8.12 00	-0.89	8.50 00	1.88	7.14-01	4.45	1.05 00	110.7
6	115	2.50	8.40 00	-0.32	8.67 00	1.50	7.08-01	4.34	1.04 00	107.8
7	118	3.01	8.75 00	0.17	8.84 00	1.02	7.01-01	4.23	1.03 00	105.1
8	121	3.51	8.82 00	0.61	9.01 00	0.38	6.95-01	4.09	1.02 00	102.5
9	124	4.10	9.28 00	1.01	9.18 00	-0.49	6.89-01	3.95	1.01 00	100.0
10	127	4.91	9.08 00	1.38	9.35 00	-1.63	6.83-01	3.79	9.96-01	97.6
11	130.	5.38	8.65 00	1.74	9.51 00	-5.96	6.77-01	3.60	9.85-01	95.4
12	133	5.66	8.13 00	2.08	9.68 00	-6.32 L	5.42 00	3.42	9.75-01	93.2
13	136	5.62	7.93 00	2.42	9.84 00	-2.47	6.03 00	3.17	9.63-01	91.2
14	140	5.64	7.87 00	2.87	1.01 01	-0.23	6.93 00	2.81	9.48-01	88.6
15	143	5.69	7.91 00	3.20	1.02 01	0.68	7.68 00	2.47	9.37-01	86.7
16	147	5.79	8.04 00	3.67	1.04 01	1.66	8.76 00	1.96	9.23-01	84.3
17	150	5.95	8.18 00	4.02	1.06 01	2.28	9.27 00	1.47	9.14-01	82.7
18	154	6.25	8.35 00	4.55	1.08 01	2.91	9.25 00	0.55	9.05-01	80.5
19	158	6.63	8.51 00	5.17	1.10 01	3.41	9.20 00	-0.93	8.97-01	78.5
20	162	7.12	8.54 00	5.83	1.11 01	3.86	9.16 00	-3.55	8.89-01	76.5
21	166	7.54	8.43 00	6.43	1.09 01	4.25	9.13 00	-7.76 L	1.05 01	74.7
22	170	7.95	8.33 00	6.91	1.07 01	4.58	9.09 00	-2.55	1.05 01	72.9
23	174	8.29	8.00 00	7.32	1.06 01	4.85	9.04 00	0.21	1.04 01	71.3
24	178	8.40	7.70 00	7.69	1.05 01	5.04	8.99 00	1.59	1.04 01	69.7
25	182	8.45	7.53 00	8.04	1.03 01	5.00	8.95 00	2.51	1.04 01	68.1
26	187	8.56	7.49 00	8.46	1.02 01	5.12	9.49 00	3.41	1.03 01	66.3
27	191	8.70	7.45 00	8.80	1.00 01	5.42	1.01 01	4.05	1.03 01	64.9
28	196	8.90	7.40 00	9.16	9.80 00	6.37	1.03 01	4.72	1.02 01	63.3
29	201	9.10	7.34 00	9.48	9.60 00	7.00	1.02 01	5.26	1.01 01	61.7
30	206	9.30	7.26 00	9.79	9.40 00	7.53	1.01 01	5.71	1.00 01	60.2
31	211	9.50	7.18 00	10.09	9.20 00	7.99	1.00 01	6.10	9.91 00	58.8
32	216	9.70	7.11 00	10.35	8.98 00	8.38	9.88 00	6.41	9.91 00	57.4
33	221	9.91	7.02 00	10.57	8.77 00	8.73	9.73 00	6.72	9.93 00	56.1
34	227	10.14	6.88 00	10.82	8.53 00	9.11	9.57 00	7.10	9.95 00	54.6
35	232	10.32	6.77 00	11.01	8.34 00	9.40	9.43 00	7.41	9.97 00	53.4
36	238	10.53	6.64 00	11.22	8.12 00	9.71	9.28 00	7.78	9.99 00	52.1
37	244	10.74	6.47 00	11.42	7.90 00	10.01	9.13 00	8.14	1.00 01	50.8
38	250	10.92	6.29 00	11.60	7.68 00	10.29	8.99 00	8.49	1.00 01	49.6
39	256	11.08	6.13 00	11.75	7.47 00	10.54	8.86 00	8.85	1.01 01	48.4
40	262	11.23	5.95 00	11.89	7.27 00	10.79	8.73 00	9.21	1.01 01	47.3
41	269	11.38	5.74 00	12.04	7.05 00	11.08	8.58 00	9.66	1.01 01	46.1
42	275	11.49	5.57 00	12.16	6.87 00	11.33	8.46 00	10.11	1.01 01	45.1
43	282	11.61	5.36 00	12.28	6.66 00	11.61	8.27 00	10.60	9.96 00	44.0
44	289	11.70	5.15 00	12.39	6.46 00	11.86	8.07 00	11.04	9.75 00	42.9
45	296	11.76	4.95 00	12.49	6.28 00	12.07	7.88 00	11.39	9.55 00	41.9
46	303	11.79	4.78 00	12.58	6.10 00	12.25	7.70 00	11.68	9.36 00	40.9
47	311	11.83	4.62 00	12.68	5.90 00	12.44	7.50 00	11.99	9.14 00	39.9
48	318	11.86	4.48 00	12.75	5.73 00	12.59	7.33 00	12.23	8.97 00	39.0
49	326	11.89	4.34 00	12.82	5.55 00	12.75	7.15 00	12.47	8.77 00	38.0
50	334	11.93	4.20 00	12.89	5.38 00	12.89	6.98 00	12.70	8.59 00	37.1
51	342	11.95	4.07 00	12.95	5.21 00	13.03	6.82 00	12.91	8.41 00	36.3
52	351	11.97	3.94 00	13.01	5.04 00	13.18	6.64 00	13.13	8.22 00	35.3
53	359	11.99	3.84 00	13.06	4.89 00	13.31	6.50 00	13.32	8.06 00	34.5
54	368	12.02	3.73 00	13.10	4.73 00	13.45	6.34 00	13.52	7.89 00	33.7
55	377	12.04	3.63 00	13.14	4.57 00	13.57	6.19 00	13.71	7.72 00	32.9
56	386	12.07	3.53 00	13.18	4.43 00	13.66	6.04 00	13.90	7.56 00	32.1
57	396	12.11	3.43 00	13.22	4.28 00	13.76	5.88 00	14.14	7.38 00	31.3
58	406	12.15	3.32 00	13.24	4.13 00	13.85	5.70 00	14.29	7.17 00	30.5
59	415	12.18	3.21 00	13.26	4.01 00	13.91	5.55 00	14.42	6.98 00	29.9
60	426	12.20	3.09 00	13.29	3.86 00	13.98	5.37 00	14.56	6.77 00	29.1
61	436	12.21	2.98 00	13.30	3.74 00	14.04	5.22 00	14.68	6.59 00	28.4
62	447	12.23	2.88 00	13.32	3.61 00	14.09	5.06 00	14.79	6.40 00	27.7
63	458	12.23	2.78 00	13.33	3.48 00	14.14	4.90 00	14.89	6.21 00	27.1
64	469	12.24	2.68 00	13.34	3.37 00	14.18	4.74 00	14.97	6.03 00	26.4

N	E(eV)	Al (13) Aluminum f_1	f_2	Si (14) Silicon f_1	f_2	P (15) Phosphorus f_1	f_2	S (16) Sulfur f_1	f_2	λ(A)
65	480	12.24	2.59 00	13.35	3.26 00	14.21	4.60 00	15.04	5.85 00	25.83
66	492	12.25	2.50 00	13.36	3.14 00	14.25	4.45 00	15.11	5.66 00	25.20
67	504	12.25	2.41 00	13.36	3.03 00	14.28	4.30 00	15.18	5.49 00	24.60
68	516	12.25	2.32 00	13.36	2.93 00	14.30	4.17 00	15.23	5.32 00	24.03
69	529	12.24	2.23 00	13.36	2.82 00	14.32	4.03 00	15.28	5.15 00	23.44
70	542	12.24	2.15 00	13.36	2.72 00	14.34	3.89 00	15.32	4.99 00	22.87
71	555	12.23	2.07 00	13.36	2.63 00	14.35	3.76 00	15.37	4.84 00	22.34
72	569	12.23	1.99 00	13.35	2.53 00	14.37	3.61 00	15.39	4.67 00	21.79
73	583	12.22	1.92 00	13.34	2.44 00	14.37	3.48 00	15.43	4.51 00	21.27
74	597	12.21	1.84 00	13.33	2.35 00	14.38	3.37 00	15.45	4.37 00	20.77
75	612	12.20	1.77 00	13.32	2.27 00	14.38	3.25 00	15.47	4.22 00	20.26
76	627	12.18	1.70 00	13.31	2.18 00	14.39	3.14 00	15.49	4.08 00	19.77
77	642	12.17	1.63 00	13.30	2.11 00	14.38	3.02 00	15.51	3.94 00	19.31
78	658	12.15	1.56 00	13.28	2.03 00	14.38	2.89 00	15.51	3.78 00	18.84
79	674	12.12	1.49 00	13.27	1.95 00	14.38	2.77 00	15.53	3.64 00	18.39
80	690	12.10	1.44 00	13.25	1.88 00	14.37	2.68 00	15.53	3.52 00	17.97
81	707	12.08	1.39 00	13.24	1.81 00	14.36	2.59 00	15.54	3.41 00	17.54
82	725	12.05	1.33 00	13.22	1.74 00	14.36	2.49 00	15.53	3.27 00	17.10
83	742	12.03	1.28 00	13.20	1.68 00	14.35	2.40 00	15.53	3.15 00	16.71
84	760	12.01	1.23 00	13.18	1.62 00	14.33	2.31 00	15.53	3.03 00	16.31
85	779	11.98	1.18 00	13.16	1.56 00	14.32	2.22 00	15.52	2.91 00	15.92
86	798	11.96	1.13 00	13.14	1.50 00	14.31	2.13 00	15.51	2.80 00	15.54
87	818	11.93	1.08 00	13.12	1.44 00	14.29	2.04 00	15.51	2.69 00	15.16
88	838	11.90	1.04 00	13.10	1.39 00	14.27	1.96 00	15.50	2.59 00	14.79
89	858	11.87	9.96-01	13.08	1.34 00	14.26	1.88 00	15.49	2.49 00	14.45
90	879	11.84	9.55-01	13.05	1.28 00	14.24	1.81 00	15.47	2.39 00	14.10
91	901	11.81	9.15-01	13.02	1.23 00	14.22	1.73 00	15.46	2.30 00	13.76
92	923	11.77	8.77-01	13.00	1.19 00	14.20	1.67 00	15.44	2.21 00	13.43
93	945	11.74	8.42-01	12.97	1.14 00	14.18	1.60 00	15.43	2.12 00	13.12
94	968	11.70	8.07-01	12.95	1.10 00	14.15	1.54 00	15.41	2.04 00	12.81
95	992	11.66	7.74-01	12.92	1.06 00	14.13	1.48 00	15.39	1.96 00	12.50
96	1016	11.62	7.42-01	12.89	1.02 00	14.11	1.42 00	15.38	1.88 00	12.20
97	1041	11.58	7.13-01	12.86	9.76-01	14.08	1.36 00	15.36	1.81 00	11.91
98	1067	11.53	6.83-01	12.82	9.38-01	14.06	1.30 00	15.33	1.73 00	11.62
99	1093	11.48	6.54-01	12.79	9.02-01	14.03	1.25 00	15.31	1.66 00	11.34
100	1119	11.43	6.28-01	12.76	8.67-01	14.00	1.20 00	15.28	1.60 00	11.08
101	1147	11.37	6.01-01	12.72	8.33-01	13.97	1.15 00	15.26	1.53 00	10.81
102	1175	11.30	5.76-01	12.68	8.00-01	13.94	1.11 00	15.24	1.47 00	10.55
103	1204	11.23	5.52-01	12.64	7.69-01	13.91	1.06 00	15.21	1.41 00	10.30
104	1233	11.15	5.29-01	12.60	7.39-01	13.88	1.02 00	15.19	1.35 00	10.06
105	1263	11.06	5.08-01	12.55	7.10-01	13.85	9.76-01	15.16	1.30 00	9.82
106	1294	10.96	4.87-01	12.50	6.82-01	13.82	9.36-01	15.13	1.25 00	9.58
107	1326	10.84	4.67-01	12.45	6.55-01	13.78	8.98-01	15.10	1.20 00	9.35
108	1358	10.70	4.49-01	12.39	6.29-01	13.74	8.62-01	15.07	1.15 00	9.13
109	1392	10.52	4.30-01	12.33	6.03-01	13.70	8.27-01	15.04	1.10 00	8.91
110	1426	10.29	4.13-01	12.25	5.79-01	13.66	7.93-01	15.01	1.06 00	8.69
111	1460	10.00	3.97-01	12.18	5.57-01	13.61	7.62-01	14.98	1.02 00	8.49
112	1496	9.54	3.80-01	12.09	5.34-01	13.56	7.31-01	14.94	9.76-01	8.29
113	1533	7.75	3.63-01	11.98	5.11-01	13.51	7.02-01	14.90	9.37-01	8.09
114	1570	6.66 K	4.13 00	11.86	4.90-01	13.45	6.75-01	14.86	9.02-01	7.90
115	1609	9.49	4.00 00	11.72	4.69-01	13.39	6.48-01	14.82	8.66-01	7.71
116	1648	10.23	3.87 00	11.54	4.49-01	13.33	6.23-01	14.78	8.33-01	7.52
117	1688	10.84	3.74 00	11.30	4.30-01	13.25	5.99-01	14.74	8.01-01	7.34
118	1730	11.24	3.62 00	10.98	4.12-01	13.16	5.75-01	14.70	7.69-01	7.17
119	1772	11.54	3.49 00	10.47	3.94-01	13.07	5.51-01	14.64	7.39-01	7.00
120	1815	11.79	3.37 00	8.48	3.76-01	12.95	5.29-01	14.58	7.09-01	6.83
121	1860	11.97	3.25 00	6.85 K	4.09 00	12.81	5.06-01	14.52	6.79-01	6.67
122	1905	12.12	3.14 00	8.20	3.96 00	12.65	4.86-01	14.45	6.52-01	6.51
123	1952	12.28	3.03 00	9.61	3.83 00	12.36	4.65-01	14.38	6.25-01	6.35
124	2000	12.44	2.92 00	11.06	3.70 00	12.07	4.46-01	14.30	5.99-01	6.20
	$\frac{E\mu(E)}{f_2}$	1559.		1497.		1358.		1312.		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	26.98		28.09		30.97		32.06		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Cl (17) f_1	Cl (17) f_2	Ar (18) f_1	Ar (18) f_2	K (19) f_1	K (19) f_2	Ca (20) f_1	Ca (20) f_2	λ(A)
0	100	5.59	1.50	6.21	1.82	6.97	2.10	7.89	2.30	124.0
1	102	5.59	1.50	6.26	1.90	7.01	2.11	7.94	2.30	121.5
2	104	5.58	1.49	6.30	1.88	7.04	2.11	7.98	2.30	119.2
3	107	5.57	1.48	6.33	1.86	7.09	2.12	8.04	2.30	115.9
4	110	5.55	1.47	6.33	1.85	7.12	2.12	8.10	2.30	112.7
5	112	5.53	1.46	6.32	1.85	7.14	2.13	8.13	2.31	110.7
6	115	5.50	1.45	6.33	1.93	7.18	2.13	8.18	2.32	107.8
7	118	5.46	1.45	6.38	1.86	7.20	2.14	8.23	2.33	105.1
8	121	5.42	1.44	6.37	1.86	7.23	2.15	8.28	2.34	102.5
9	124	5.37	1.43	6.36	1.89	7.26	2.15	8.32	2.35	100.0
10	127	5.32	1.42	6.37	1.88	7.28	2.16	8.37	2.35	97.6
11	130	5.26	1.41	6.36	1.88	7.31	2.16	8.42	2.36	95.4
12	133	5.20	1.40	6.36	1.88	7.34	2.15	8.47	2.37	93.2
13	136·	5.13	1.38	6.36	1.87	7.36	2.14	8.51	2.37	91.2
14	140	5.02	1.36	6.33	1.85	7.37	2.13	8.56	2.38	88.6
15	143	4.92	1.35	6.31	1.84	7.38	2.11	8.59	2.39	86.7
16	147	4.78	1.33	6.28	1.82	7.38	2.10	8.62	2.40	84.3
17	150	4.66	1.32	6.25	1.81	7.38	2.09	8.65	2.41	82.7
18	154	4.49	1.30	6.20	1.79	7.37	2.08	8.68	2.39	80.5
19	158	4.28	1.29	6.14	1.76	7.36	2.06	8.71	2.37	78.5
20	162	4.06	1.27	6.07	1.74	7.35	2.04	8.74	2.35	76.5
21	166	3.81	1.25	5.99	1.71	7.33	2.02	8.76	2.33	74.7
22	170	3.50	1.23	5.89	1.69	7.30	2.00	8.77	2.32	72.9
23	174	3.14	1.21	5.79	1.67	7.26	1.98	8.78	2.30	71.3
24	178	2.73	1.19	5.67	1.65	7.22	1.96	8.78	2.29	69.7
25	182	2.22	1.17	5.54	1.64	7.17	1.94	8.78	2.28	68.1
26	187	1.35	1.15	5.36	1.61	7.10	1.91	8.77	2.25	66.3
27	191	0.52	1.13	5.19	1.59	7.04	1.89	8.77	2.24	64.9
28	196	-1.47	1.11	4.95	1.56	6.95	1.87	8.75	2.21	63.3
29	201	-7.71 L	1.09	4.67	1.54	6.85	1.84	8.72	2.19	61.7
30	206	-4.62	9.79	4.35	1.52	6.73	1.81	8.69	2.16	60.2
31	211	-1.13	11.17	3.97	1.49	6.60	1.79	8.66	2.14	58.8
32	216	0.82	11.49	3.49	1.47	6.45	1.76	8.61	2.11	57.4
33	221	2.07	11.52	2.94	1.45	6.29	1.73	8.55	2.08	56.1
34	227	3.23	11.56	2.05	1.43	6.07	1.70	8.48	2.04	54.6
35	232	4.00	11.59	0.88	1.41	5.85	1.68	8.40	2.02	53.4
36	238	4.76	11.63	-2.15	1.39	5.56	1.65	8.31	1.98	52.1
37	244	5.44	11.66	-8.20 L	1.37	5.22	1.62	8.19	1.95	50.8
38	250	6.07	11.70	-1.96	12.30	4.82	1.59	8.07	1.92	49.6
39	256	6.64	11.73	0.65	12.23	4.33	1.56	7.92	1.90	48.4
40	262	7.19	11.77	2.55	12.16	3.76	1.53	7.75	1.87	47.3
41	269	7.84	11.81	3.97	12.08	2.91	1.50	7.54	1.84	46.1
42	275	8.42	11.84	4.85	12.01	1.89	1.47	7.33	1.81	45.1
43	282	9.08	11.70	5.71	11.94	-0.09	1.44	7.04	1.78	44.0
44	289	9.65	11.49	6.45	11.86	-3.00	1.41	6.71	1.76	42.9
45	296	10.13	11.29	7.08	11.79	-10.45 L	30.98	6.33	1.73	41.9
46	303	10.54	11.10	7.64	11.73	-2.91	26.19	5.85	1.71	40.9
47	311	10.97	10.89	8.23	11.65	2.11	21.73	5.23	1.68	39.9
48	318	11.31	10.72	8.69	11.59	3.82	18.52	4.51	1.65	39.0
49	326	11.67	10.52	9.17	11.51	5.25	15.50	3.31	1.63	38.0
50	334	12.00	10.34	9.63	11.45	6.42	14.00	1.33	1.60	37.1
51	342	12.31	10.16	10.07	11.38	7.41	13.62	-2.35	1.58	36.3
52	351	12.64	9.97	10.52	11.30	8.37	13.22	-7.24 L	14.62	35.3
53	359	12.91	9.81	10.91	11.24	9.10	12.88	0.00	14.34	34.5
54	368	13.21	9.64	11.34	11.17	9.88	12.90	3.64	14.05	33.7
55	377	13.51	9.47	11.76	11.11	10.61	12.97	5.53	13.76	32.9
56	386	13.83	9.31	12.23	11.04	11.38	13.04	6.93	13.49	32.1
57	396	14.19	9.01	12.76	10.90	12.18	13.02	8.24	13.22	31.3
58	406	14.42	8.75	13.21	10.64	12.67	12.68	9.11	13.19	30.5
59	415	14.62	8.53	13.54	10.41	13.15	12.38	9.77	13.17	29.9
60	426	14.85	8.26	13.91	10.14	13.70	12.04	10.26	13.14	29.1
61	436	15.04	8.02	14.22	9.91	14.16	11.74	10.87	13.11	28.4
62	447	15.21	7.76	14.52	9.67	14.59	11.44	11.71	13.08	27.7
63	458	15.36	7.52	14.81	9.42	14.97	11.12	12.68	12.88	27.1
64	469	15.50	7.28	15.06	9.17	15.31	10.81	13.39	12.54	26.4

N	E(eV)	Cl (17) Chlorine f_1	Cl (17) Chlorine f_2	Ar (18) Argon f_1	Ar (18) Argon f_2	K (19) Potassium f_1	K (19) Potassium f_2	Ca (20) Calcium f_1	Ca (20) Calcium f_2	λ(A)
65	480	15.63	7.07	15.28	8.93	15.63	10.52	14.02	12.21	25.83
66	492	15.75	6.83	15.49	8.68	15.93	10.21	14.60	11.87	25.20
67	504	15.85	6.61	15.69	8.44	16.21	9.92	15.08	11.54	24.60
68	516	15.95	6.40	15.87	8.22	16.46	9.64	15.52	11.24	24.03
69	529	16.04	6.18	16.05	7.98	16.71	9.35	15.94	10.92	23.44
70	542	16.12	5.97	16.22	7.75	16.92	9.07	16.31	10.61	22.87
71	555	16.19	5.78	16.38	7.54	17.11	8.80	16.64	10.32	22.34
72	569	16.25	5.57	16.53	7.29	17.29	8.50	16.97	10.00	21.79
73	583	16.31	5.38	16.65	7.05	17.46	8.23	17.25	9.70	21.27
74	597	16.36	5.20	16.76	6.84	17.60	7.98	17.50	9.42	20.77
75	612	16.41	5.02	16.87	6.62	17.75	7.72	17.74	9.14	20.26
76	627	16.44	4.85	16.97	6.41	17.87	7.48	17.96	8.87	19.77
77	642	16.48	4.68	17.06	6.21	17.98	7.24	18.16	8.60	19.31
78	658	16.51	4.52	17.15	5.98	18.09	6.97	18.34	8.30	18.84
79	674	16.53	4.36	17.21	5.77	18.18	6.72	18.51	8.02	18.39
80	690	16.55	4.21	17.26	5.60	18.26	6.53	18.65	7.81	17.97
81	707	16.57	4.06	17.32	5.44	18.34	6.34	18.79	7.59	17.54
82	725	16.58	3.91	17.39	5.25	18.40	6.11	18.92	7.33	17.10
83	742	16.59	3.77	17.44	5.07	18.46	5.91	19.03	7.10	16.71
84	760	16.60	3.64	17.49	4.90	18.52	5.71	19.13	6.86	16.31
85	779	16.61	3.51	17.54	4.73	18.56	5.51	19.23	6.63	15.92
86	798	16.61	3.38	17.58	4.55	18.60	5.31	19.31	6.39	15.54
87	818	16.61	3.25	17.61	4.37	18.64	5.12	19.38	6.17	15.16
88	838	16.61	3.13	17.63	4.21	18.67	4.94	19.45	5.95	14.79
89	858	16.60	3.02	17.64	4.05	18.70	4.76	19.51	5.75	14.45
90	879	16.60	2.91	17.65	3.90	18.71	4.59	19.56	5.55	14.10
91	901	16.59	2.80	17.66	3.75	18.73	4.43	19.60	5.35	13.76
92	923	16.58	2.70	17.66	3.62	18.75	4.27	19.64	5.17	13.43
93	945	16.57	2.60	17.66	3.48	18.76	4.15	19.68	4.99	13.12
94	968	16.55	2.50	17.66	3.35	18.76	4.05	19.71	4.82	12.81
95	992	16.54	2.41	17.66	3.22	18.77	3.94	19.73	4.65	12.50
96	1016	16.52	2.32	17.65	3.10	18.77	3.84	19.75	4.49	12.20
97	1041	16.51	2.23	17.64	2.98	18.77	3.69	19.77	4.32	11.91
98	1067	16.49	2.14	17.63	2.86	18.76	3.54	19.78	4.16	11.62
99	1093	16.47	2.06	17.62	2.75	18.75	3.40	19.79	4.01	11.34
100	1119	16.45	1.98	17.61	2.64	18.75	3.27	19.79	3.86	11.08
101	1147	16.43	1.91	17.59	2.54	18.74	3.14	19.79	3.72	10.81
102	1175	16.41	1.83	17.57	2.44	18.72	3.01	19.79	3.58	10.55
103	1204	16.38	1.76	17.55	2.34	18.71	2.90	19.79	3.45	10.30
104	1233	16.36	1.69	17.53	2.25	18.69	2.78	19.78	3.32	10.06
105	1263	16.34	1.63	17.51	2.16	18.68	2.67	19.78	3.20	9.82
106	1294	16.31	1.57	17.49	2.07	18.66	2.57	19.77	3.08	9.58
107	1326	16.28	1.50	17.46	1.99	18.64	2.47	19.75	2.97	9.35
108	1358	16.26	1.45	17.43	1.91	18.62	2.37	19.74	2.86	9.13
109	1392	16.23	1.39	17.40	1.83	18.60	2.28	19.73	2.75	8.91
110	1426	16.20	1.33	17.37	1.76	18.57	2.19	19.71	2.65	8.69
111	1460	16.17	1.28	17.34	1.69	18.55	2.10	19.69	2.56	8.49
112	1496	16.14	1.23	17.31	1.62	18.53	2.02	19.67	2.46	8.29
113	1533	16.11	1.18	17.28	1.56	18.50	1.94	19.65	2.36	8.09
114	1570	16.08	1.14	17.25	1.50	18.48	1.87	19.63	2.27	7.90
115	1609	16.04	1.10	17.21	1.44	18.45	1.80	19.61	2.17	7.71
116	1648	16.01	1.05	17.18	1.39	18.42	1.73	19.59	2.09	7.52
117	1688	15.97	1.01	17.15	1.33	18.39	1.66	19.56	2.00	7.34
118	1730	15.94	0.98	17.11	1.28	18.36	1.60	19.54	1.92	7.17
119	1772	15.90	0.94	17.08	1.23	18.33	1.53	19.51	1.84	7.00
120	1815	15.86	0.90	17.05	1.18	18.30	1.48	19.49	1.77	6.83
121	1860	15.81	0.87	17.01	1.14	18.27	1.42	19.46	1.69	6.67
122	1905	15.77	0.83	16.97	1.09	18.23	1.36	19.44	1.63	6.51
123	1952	15.72	0.80	16.93	1.05	18.20	1.31	19.41	1.56	6.35
124	2000	15.66	0.77	16.89	1.01	18.16	1.26	19.38	1.50	6.20
	$\frac{E\mu(E)}{f_2}$	1186.		1053.		1076.		1049.		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	35.45		39.95		39.09		40.08		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Sc (21) f_1	Sc (21) f_2	Ti (22) f_1	Ti (22) f_2	V (23) f_1	V (23) f_2	Cr (24) f_1	Cr (24) f_2	λ(A)
0	100	8.50	2.88	9.23	3.46	9.84	4.20	10.55	5.66	124.0
1	102	8.56	2.88	9.29	3.44	9.93	4.16	10.65	5.59	121.5
2	104	8.62	2.88	9.36	3.43	10.00	4.12	10.75	5.53	119.2
3	107	8.69	2.89	9.44	3.41	10.10	4.06	10.88	5.44	115.9
4	110	8.76	2.90	9.52	3.40	10.18	4.03	11.02	5.39	112.7
5	112	8.80	2.91	9.57	3.40	10.25	4.04	11.11	5.38	110.7
6	115	8.87	2.91	9.65	3.41	10.35	4.04	11.22	5.36	107.8
7	118	8.93	2.92	9.73	3.41	10.44	4.03	11.36	5.33	105.1
8	121	8.99	2.92	9.80	3.40	10.52	4.02	11.47	5.31	102.5
9	124	9.05	2.92	9.87	3.40	10.61	4.01	11.58	5.28	100.0
10	127	9.11	2.93	9.94	3.40	10.70	4.00	11.70	5.26	97.6
11	130	9.18	2.93	10.02	3.40	10.79	4.00	11.82	5.23	95.4
12	133	9.25	2.93	10.09	3.40	10.90	3.99	11.91	5.21	93.2
13	136	9.30	2.94	10.16	3.39	10.97	3.98	12.04	5.19	91.2
14	140	9.37	2.94	10.24	3.39	11.06	3.97	12.17	5.16	88.6
15	143	9.42	2.94	10.30	3.39	11.13	3.97	12.26	5.14	86.7
16	147	9.47	2.95	10.37	3.39	11.23	3.96	12.36	5.11	84.3
17	150	9.52	2.95	10.42	3.39	11.29	3.96	12.45	5.09	82.7
18	154	9.57	2.93	10.48	3.37	11.36	3.93	12.57	5.05	80.5
19	158	9.62	2.91	10.55	3.34	11.44	3.89	12.69	4.99	78.5
20	162	9.67	2.88	10.62	3.31	11.52	3.86	12.79	4.93	76.5
21	166	9.72	2.86	10.68	3.28	11.60	3.82	12.90	4.87	74.7
22	170	9.76	2.84	10.72	3.25	11.66	3.79	12.98	4.82	72.9
23	174	9.79	2.82	10.78	3.23	11.73	3.76	13.05	4.77	71.3
24	178	9.82	2.80	10.82	3.21	11.78	3.74	13.14	4.73	69.7
25	182	9.84	2.78	10.85	3.19	11.84	3.72	13.20	4.70	68.1
26	187	9.87	2.76	10.91	3.16	11.90	3.68	13.31	4.63	66.3
27	191	9.89	2.73	10.94	3.14	11.95	3.64	13.38	4.58	64.9
28	196	9.91	2.70	10.98	3.10	12.01	3.60	13.47	4.52	63.3
29	201	9.92	2.67	11.01	3.07	12.06	3.56	13.54	4.46	61.7
30	206	9.93	2.64	11.04	3.03	12.10	3.52	13.61	4.40	60.2
31	211	9.93	2.61	11.06	3.00	12.15	3.48	13.67	4.34	58.8
32	216	9.93	2.57	11.09	2.96	12.19	3.44	13.73	4.28	57.4
33	221	9.92	2.54	11.10	2.92	12.21	3.39	13.79	4.21	56.1
34	227	9.90	2.50	11.11	2.88	12.25	3.34	13.85	4.14	54.6
35	232	9.87	2.46	11.11	2.84	12.27	3.29	13.90	4.08	53.4
36	238	9.84	2.43	11.11	2.80	12.29	3.25	13.95	4.01	52.1
37	244	9.80	2.39	11.11	2.75	12.31	3.20	14.00	3.95	50.8
38	250	9.75	2.35	11.09	2.71	12.32	3.15	14.04	3.88	49.6
39	256	9.69	2.32	11.07	2.68	12.33	3.11	14.07	3.82	48.4
40	262	9.62	2.29	11.05	2.64	12.33	3.06	14.10	3.76	47.3
41	269	9.53	2.25	11.01	2.60	12.33	3.02	14.13	3.70	46.1
42	275	9.44	2.22	10.96	2.56	12.32	2.98	14.16	3.64	45.1
43	282	9.32	2.18	10.92	2.52	12.30	2.93	14.16	3.57	44.0
44	289	9.19	2.14	10.85	2.47	12.28	2.87	14.19	3.50	42.9
45	296	9.03	2.09	10.78	2.43	12.25	2.82	14.19	3.44	41.9
46	303	8.86	2.06	10.70	2.38	12.21	2.77	14.20	3.37	40.9
47	311	8.64	2.01	10.58	2.33	12.17	2.72	14.17	3.30	39.9
48	318	8.41	1.98	10.47	2.29	12.11	2.67	14.19	3.24	39.0
49	326	8.11	1.94	10.34	2.25	12.04	2.62	14.17	3.18	38.0
50	334	7.77	1.90	10.18	2.21	11.96	2.57	14.15	3.11	37.1
51	342	7.38	1.87	10.01	2.17	11.87	2.53	14.12	3.05	36.3
52	351	6.81	1.83	9.78	2.13	11.76	2.48	14.08	2.99	35.3
53	359	6.19	1.80	9.55	2.09	11.65	2.44	14.04	2.94	34.5
54	368	5.34	1.76	9.26	2.05	11.51	2.39	13.98	2.88	33.7
55	377	4.09	1.73	8.91	2.01	11.35	2.35	13.92	2.82	32.9
56	386	1.91	1.69	8.50	1.97	11.17	2.30	13.84	2.77	32.1
57	396	-2.86 L	1.66	7.96	1.93	10.96	2.26	13.73	2.71	31.3
58	406	-5.14	15.45	7.30	1.89	10.68	2.21	13.65	2.64	30.5
59	415	2.31	15.14	6.50	1.85	10.42	2.16	13.55	2.59	29.9
60	426	5.66	14.78	5.19	1.81	10.03	2.11	13.40	2.52	29.1
61	436	7.46	14.47	3.47	1.77	9.63	2.07	13.25	2.46	28.4
62	447	8.92	14.14	-2.62	1.73	9.12	2.02	13.07	2.41	27.7
63	458	9.94	13.79	-5.88 L	15.50	8.46	1.97	12.86	2.35	27.1
64	469	10.63	13.44	3.13	15.08	7.57	1.93	12.64	2.29	26.4

N	E(eV)	Sc (21) Scandium f_1	Sc (21) Scandium f_2	Ti (22) Titanium f_1	Ti (22) Titanium f_2	V (23) Vanadium f_1	V (23) Vanadium f_2	Cr (24) Chromium f_1	Cr (24) Chromium f_2	λ(A)
65	480	11.16	13.11	6.59	14.68	6.44	1.89	12.38	2.24	25.83
66	492	11.65	13.38	8.43	14.26	4.58	1.85	12.05	2.18	25.20
67	504	12.45	13.64	9.88	13.87	-1.64	1.81	11.66	2.13	24.60
68	516	13.40	13.55	10.95	13.50	-6.27 L	15.74	11.19	2.08	24.03
69	529	14.30	13.11	11.75	13.11	4.25	15.27	10.63	2.02	23.44
70	542	14.96	12.75	12.20	12.75	7.65	14.82	9.84	1.97	22.87
71	555	15.56	12.41	12.67	12.40	9.52	14.40	8.88	1.92	22.34
72	569	16.08	12.04	13.70	13.48	10.95	13.94	7.34	1.86	21.79
73	583	16.53	11.68	14.69	13.53	11.99	13.85	4.39	1.81	21.27
74	597	16.94	11.35	15.51	13.15	12.54	13.89	-6.97 L	1.76	20.77
75	612	17.34	11.01	16.23	12.76	13.24	13.94	2.56	15.74	20.26
76	627	17.68	10.69	16.78	12.39	14.09	13.99	8.74	15.12	19.77
77	642	17.99	10.37	17.27	12.03	15.22	13.88	10.85	14.53	19.31
78	658	18.28	10.01	17.74	11.64	15.11	13.42	11.85	13.95	18.84
79	674	18.54	9.68	18.14	11.27	16.88	12.98	12.69	13.40	18.39
80	690	18.77	9.41	18.51	10.98	17.48	12.64	14.12	13.90	17.97
81	707	19.00	9.16	18.88	10.69	18.04	12.31	15.58	14.53	17.54
82	725	19.21	8.85	19.18	10.34	18.53	11.92	16.55	14.06	17.10
83	742	19.38	8.57	19.44	10.02	18.95	11.58	17.35	13.65	16.71
84	760	19.55	8.30	19.70	9.70	19.34	11.23	18.02	13.24	16.31
85	779	19.70	8.02	19.95	9.38	19.72	10.88	18.63	12.82	15.92
86	798	19.84	7.75	20.16	9.08	20.05	10.54	19.22	12.42	15.54
87	818	19.96	7.48	20.36	8.77	20.35	10.19	19.72	12.03	15.16
88	838	20.08	7.22	20.54	8.48	20.62	9.87	20.14	11.65	14.79
89	858	20.18	6.98	20.69	8.21	20.87	9.56	20.55	11.29	14.45
90	879	20.27	6.74	20.84	7.94	21.09	9.25	20.91	10.94	14.10
91	901	20.35	6.50	20.98	7.67	21.30	8.95	21.24	10.58	13.76
92	923	20.42	6.28	21.09	7.41	21.49	8.66	21.53	10.25	13.43
93	945	20.49	6.06	21.20	7.16	21.65	8.38	21.80	9.92	13.12
94	968	20.55	5.85	21.30	6.91	21.81	8.10	22.05	9.60	12.81
95	992	20.60	5.64	21.39	6.67	21.95	7.82	22.27	9.27	12.50
96	1016	20.64	5.44	21.46	6.44	22.08	7.56	22.47	8.97	12.20
97	1041	20.68	5.25	21.53	6.22	22.19	7.30	22.63	8.66	11.91
98	1067	20.71	5.06	21.60	5.99	22.29	7.04	22.83	8.35	11.62
99	1093	20.74	4.88	21.65	5.78	22.38	6.79	22.98	8.06	11.34
100	1119	20.76	4.71	21.70	5.58	22.46	6.56	23.11	7.78	11.08
101	1147	20.78	4.53	21.74	5.38	22.54	6.33	23.24	7.51	10.81
102	1175	20.79	4.37	21.77	5.19	22.60	6.11	23.35	7.24	10.55
103	1204	20.80	4.21	21.80	5.00	22.66	5.89	23.43	6.99	10.30
104	1233	20.81	4.06	21.83	4.83	22.71	5.69	23.52	6.75	10.06
105	1263	20.81	3.92	21.84	4.66	22.75	5.49	23.62	6.51	9.82
106	1294	20.81	3.77	21.86	4.48	22.78	5.29	23.69	6.27	9.58
107	1326	20.81	3.63	21.87	4.32	22.81	5.10	23.75	6.05	9.35
108	1358	20.80	3.50	21.88	4.16	22.84	4.92	23.81	5.83	9.13
109	1392	20.79	3.37	21.88	4.01	22.86	4.73	23.85	5.62	8.91
110	1426	20.79	3.25	21.88	3.86	22.87	4.56	23.89	5.41	8.69
111	1460	20.78	3.13	21.88	3.72	22.89	4.40	23.92	5.22	8.49
112	1496	20.76	3.01	21.87	3.58	22.90	4.24	23.94	5.03	8.29
113	1533	20.75	2.90	21.87	3.44	22.90	4.08	23.98	4.83	8.09
114	1570	20.73	2.79	21.86	3.31	22.90	3.93	24.00	4.65	7.90
115	1609	20.71	2.68	21.85	3.18	22.90	3.78	24.02	4.47	7.71
116	1648	20.69	2.58	21.84	3.06	22.89	3.64	24.03	4.30	7.52
117	1688	20.67	2.47	21.82	2.94	22.89	3.50	24.04	4.13	7.34
118	1730	20.65	2.39	21.80	2.83	22.88	3.36	24.04	3.97	7.17
119	1772	20.62	2.30	21.79	2.72	22.87	3.24	24.02	3.82	7.00
120	1815	20.60	2.21	21.77	2.61	22.85	3.11	24.04	3.67	6.83
121	1860	20.57	2.13	21.75	2.51	22.84	2.99	24.04	3.52	6.67
122	1905	20.54	2.04	21.73	2.41	22.82	2.88	24.02	3.38	6.51
123	1952	20.51	1.97	21.70	2.32	22.80	2.76	24.00	3.24	6.35
124	2000	20.48	1.89	21.67	2.22	22.78	2.66	23.98	3.11	6.20
	$\frac{E_u(E)}{f_2}$	935.5		878.0		825.6		808.9		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	44.96		47.90		50.94		52.00		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Mn (25)		Fe (26)		Co (27)		Ni (28)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	10.07	6.60	9.74	7.91	9.54	8.59	9.19	9.60	124.0
1	102	10.26	6.43	9.96	7.89	9.68	8.61	9.36	9.64	121.5
2	104	10.42	6.26	10.15	7.87	9.82	8.64	9.52	9.67	119.2
3	107	10.63	6.03	10.40	7.84	10.03	8.67	9.76	9.72	115.9
4	110	10.81	5.92	10.62	7.81	10.24	8.70	10.00	9.77	112.7
5	112	10.93	5.91	10.75	7.79	10.37	8.72	10.16	9.80	110.7
6	115	11.09	5.91	10.95	7.76	10.58	8.75	10.41	9.85	107.8
7	118	11.25	5.89	11.15	7.73	10.80	8.78	10.65	9.89	105.1
8	121	11.40	5.87	11.33	7.70	11.02	8.81	10.90	9.94	102.5
9	124	11.55	5.85	11.51	7.68	11.24	8.84	11.15	9.98	100.0
10	127	11.70	5.84	11.68	7.65	11.47	8.87	11.41	10.02	97.6
11	130	11.86	5.82	11.86	7.63	11.73	8.90	11.70	10.07	95.4
12	133	12.00	5.81	12.05	7.57	11.98	8.85	12.00	10.02	93.2
13	136	12.13	5.79	12.20	7.52	12.18	8.79	12.22	9.97	91.2
14	140	12.29	5.77	12.41	7.46	12.44	8.73	12.52	9.91	88.6
15	143	12.41	5.76	12.55	7.41	12.62	8.68	12.73	9.87	86.7
16	147	12.56	5.74	12.73	7.35	12.86	8.62	13.01	9.81	84.3
17	150	12.66	5.73	12.86	7.31	13.03	8.57	13.20	9.77	82.7
18	154	12.80	5.68	13.03	7.25	13.24	8.52	13.45	9.72	80.5
19	158	12.94	5.62	13.21	7.20	13.46	8.46	13.71	9.66	78.5
20	162	13.08	5.56	13.38	7.13	13.68	8.39	13.97	9.59	76.5
21	166	13.21	5.50	13.54	7.05	13.89	8.29	14.21	9.50	74.7
22	170	13.33	5.44	13.68	6.96	14.07	8.21	14.42	9.41	72.9
23	174	13.43	5.40	13.82	6.89	14.24	8.12	14.63	9.33	71.3
24	178	13.53	5.36	13.95	6.81	14.40	8.04	14.83	9.25	69.7
25	182	13.63	5.32	14.07	6.74	14.56	7.96	15.02	9.17	68.1
26	187	13.74	5.25	14.22	6.65	14.75	7.86	15.26	9.07	66.3
27	191	13.83	5.20	14.34	6.58	14.91	7.78	15.44	8.99	64.9
28	196	13.94	5.13	14.47	6.48	15.08	7.66	15.66	8.86	63.3
29	201	14.03	5.06	14.60	6.38	15.24	7.55	15.86	8.74	61.7
30	206	14.13	5.00	14.71	6.29	15.39	7.45	16.06	8.63	60.2
31	211	14.22	4.94	14.82	6.20	15.54	7.34	16.24	8.51	58.8
32	216	14.30	4.87	14.93	6.11	15.68	7.23	16.41	8.38	57.4
33	221	14.37	4.80	15.02	6.01	15.80	7.12	16.57	8.26	56.1
34	227	14.45	4.72	15.13	5.91	15.94	6.99	16.74	8.11	54.6
35	232	14.51	4.65	15.21	5.82	16.05	6.89	16.87	8.00	53.4
36	238	14.58	4.58	15.31	5.73	16.17	6.77	17.04	7.87	52.1
37	244	14.65	4.50	15.40	5.62	16.29	6.65	17.19	7.73	50.8
38	250	14.71	4.43	15.48	5.52	16.40	6.53	17.33	7.59	49.6
39	256	14.76	4.37	15.55	5.42	16.50	6.41	17.45	7.46	48.4
40	262	14.80	4.30	15.61	5.33	16.59	6.30	17.57	7.33	47.3
41	269	14.85	4.23	15.69	5.23	16.69	6.18	17.70	7.19	46.1
42	275	14.89	4.17	15.75	5.13	16.77	6.07	17.81	7.06	45.1
43	282	14.93	4.09	15.80	5.03	16.85	5.94	17.92	6.92	44.0
44	289	14.96	4.01	15.85	4.93	16.93	5.82	18.02	6.78	42.9
45	296	14.98	3.94	15.90	4.84	17.00	5.71	18.12	6.65	41.9
46	303	15.00	3.87	15.94	4.74	17.06	5.60	18.21	6.52	40.9
47	311	15.03	3.79	15.98	4.64	17.13	5.47	18.30	6.37	39.9
48	318	15.03	3.72	16.00	4.55	17.17	5.37	18.37	6.24	39.0
49	326	15.04	3.65	16.03	4.45	17.22	5.25	18.45	6.10	38.0
50	334	15.04	3.58	16.05	4.35	17.27	5.14	18.51	5.97	37.1
51	342	15.03	3.52	16.06	4.26	17.30	5.02	18.57	5.84	36.3
52	351	15.02	3.45	16.07	4.16	17.34	4.90	18.63	5.70	35.3
53	359	15.00	3.39	16.07	4.08	17.36	4.80	18.68	5.58	34.5
54	368	14.97	3.32	16.07	3.98	17.39	4.69	18.72	5.44	33.7
55	377	14.94	3.26	16.06	3.89	17.40	4.58	18.76	5.32	32.9
56	386	14.89	3.20	16.04	3.81	17.41	4.48	18.79	5.20	32.1
57	396	14.85	3.13	16.02	3.71	17.41	4.37	18.82	5.07	31.3
58	406	14.77	3.06	15.98	3.62	17.41	4.26	18.84	4.94	30.5
59	415	14.71	2.99	15.95	3.54	17.40	4.17	18.85	4.83	29.9
60	426	14.61	2.92	15.89	3.45	17.38	4.06	18.86	4.70	29.1
61	436	14.52	2.86	15.84	3.37	17.36	3.96	18.87	4.59	28.4
62	447	14.41	2.79	15.77	3.29	17.32	3.86	18.86	4.47	27.7
63	458	14.28	2.72	15.69	3.21	17.28	3.76	18.85	4.36	27.1
64	469	14.12	2.66	15.59	3.13	17.23	3.67	18.83	4.25	26.4

N	E(eV)	Mn (25) Manganese f_1	Mn (25) Manganese f_2	Fe (26) Iron f_1	Fe (26) Iron f_2	Co (27) Cobalt f_1	Co (27) Cobalt f_2	Ni (28) Nickel f_1	Ni (28) Nickel f_2	λ(A)
65	480	13.96	2.60	15.49	3.06	17.17	3.58	18.81	4.14	25.83
66	492	13.76	2.54	15.36	2.98	17.10	3.48	18.78	4.03	25.20
67	504	13.53	2.48	15.22	2.91	17.02	3.39	18.74	3.92	24.60
68	516	13.28	2.42	15.06	2.84	16.93	3.30	18.69	3.82	24.03
69	529	12.96	2.36	14.87	2.76	16.82	3.21	18.63	3.72	23.44
70	542	12.57	2.30	14.66	2.69	16.69	3.13	18.56	3.62	22.87
71	555	12.14	2.24	14.42	2.63	16.56	3.05	18.49	3.52	22.34
72	569	11.56	2.18	14.12	2.55	16.40	2.97	18.40	3.42	21.79
73	583	10.82	2.13	13.78	2.49	16.21	2.89	18.29	3.33	21.27
74	597	9.78	2.07	13.37	2.43	16.00	2.82	18.18	3.23	20.77
75	612	8.11	2.02	12.86	2.36	15.75	2.74	18.04	3.14	20.26
76	627	5.68	1.96	12.26	2.31	15.46	2.67	17.89	3.05	19.77
77	642	-0.58 L	11.84	11.48	2.24	15.14	2.60	17.72	2.97	19.31
78	658	4.59	12.89	10.28	2.17	14.73	2.52	17.51	2.88	18.84
79	674	7.94	14.01	8.79	2.10	14.26	2.45	17.29	2.80	18.39
80	690	10.35	15.19	5.77	2.05	13.65	2.39	17.03	2.72	17.97
81	707	12.57	14.77	-7.08 L	2.01	12.91	2.33	16.73	2.64	17.54
82	725	13.81	14.31	4.35	16.45	11.85	2.27	16.34	2.56	17.10
83	742	14.71	13.84	10.40	15.94	10.18	2.21	15.93	2.48	16.71
84	760	15.16	13.95	12.70	15.42	5.68	2.14	15.38	2.41	16.31
85	779	16.11	14.57	14.22	14.91	-5.15 L	16.74	14.71	2.34	15.92
86	798	17.45	14.13	15.08	14.44	7.92	16.28	13.78	2.28	15.54
87	818	18.38	13.63	15.64	14.43	11.17	15.82	12.42	2.23	15.16
88	838	19.12	13.16	16.85	15.12	13.50	15.39	9.00	2.17	14.79
89	858	19.75	12.73	18.03	14.77	15.19	14.97	4.98 L	7.37	14.45
90	879	20.30	12.35	19.08	14.28	16.35	14.50	7.47	10.89	14.10
91	901	20.80	11.97	19.87	13.79	16.96	14.01	10.21	15.92	13.76
92	923	21.26	11.61	20.56	13.33	17.61	14.91	13.55	15.39	13.43
93	945	21.65	11.25	21.14	12.91	19.02	14.82	15.61	14.92	13.12
94	968	22.00	10.89	21.64	12.50	20.07	14.29	16.91	14.43	12.81
95	992	22.34	10.54	22.12	12.10	20.96	13.77	17.63	14.21	12.50
96	1016	22.63	10.20	22.55	11.72	21.66	13.30	18.72	15.30	12.20
97	1041	22.90	9.86	22.93	11.34	22.26	12.88	20.23	14.80	11.91
98	1067	23.13	9.52	23.26	10.95	22.78	12.44	21.19	14.30	11.62
99	1093	23.36	9.20	23.57	10.59	23.26	12.04	22.02	13.82	11.34
100	1119	23.54	8.90	23.83	10.24	23.66	11.65	22.71	1..37	11.08
101	1147	23.73	8.59	24.09	9.89	24.05	11.26	23.31	12.91	10.81
102	1175	23.90	8.30	24.33	9.56	24.39	10.89	23.85	12.48	10.55
103	1204	24.05	8.01	24.54	9.24	24.70	10.53	24.33	12.06	10.30
104	1233	24.18	7.74	24.72	8.93	24.97	10.19	24.74	11.66	.0.06
105	1263	24.29	7.48	24.89	8.63	25.22	9.85	25.12	11.27	9.82
106	1294	24.40	7.22	25.05	8.33	25.45	9.51	25.47	10.88	9.58
107	1326	24.50	6.96	25.19	8.03	25.65	9.18	25.77	10.50	9.35
108	1358	24.58	6.72	25.31	7.76	25.84	8.87	26.05	10.14	9.13
109	1392	24.66	6.48	25.42	7.48	26.01	8.56	26.31	9.79	8.91
110	1426	24.72	6.25	25.52	7.22	26.16	8.27	26.53	9.45	8.69
111	1460	24.79	6.04	25.61	6.97	26.30	7.99	26.73	9.13	8.49
112	1496	24.84	5.82	25.69	6.72	26.42	7.71	26.92	8.81	8.29
113	1533	24.88	5.60	25.76	6.47	26.53	7.43	27.09	8.48	8.09
114	1570	24.91	5.40	25.82	6.24	26.63	7.17	27.24	8.18	7.90
115	1609	24.95	5.20	25.88	6.01	26.72	6.91	27.38	7.88	7.71
116	16 :	24.97	5.01	25.92	5.79	26.79	6.67	27.49	7.59	7.52
117	1688	24.99	4.83	25.96	5.58	26.86	6.43	27.60	7.31	7.34
118	1730	25.01	4.65	25.99	5.38	26.92	6.20	27.71	7.04	7.17
119	1772	25.03	4.47	26.02	5.18	26.97	5.97	27.80	6.78	7.00
120	1815	25.03	4.30	26.04	4.98	27.01	5.75	27.88	6.53	6.83
121	1860	25.03	4.13	26.06	4.79	27.05	5.53	27.95	6.28	6.67
122	1905	25.03	3.97	26.07	4.61	27.08	5.32	28.02	6.05	6.51
123	1952	25.04	3.82	26.08	4.43	27.11	5.12	28.08	5.82	6.35
124	2000	25.04	3.67	26.08	4.26	27.13	4.93	28.12	5.60	6.20
	$\frac{E\mu(E)}{f_2}$	765.5		753.1		713.6		716.4		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	54.94		55.85		58.93		58.71		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Cu (29)		Zn (30)		Ga (31)		Ge (32)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	6.18	11.14	5.99	12.23	6.35	11.02	5.24	10.19	124.0
1	102	6.30	11.39	6.37	12.26	6.58	11.12	5.38	10.34	121.5
2	104	6.51	11.64	6.70	12.29	6.81	11.23	5.52	10.50	119.2
3	107	6.89	12.01	7.12	12.33	7.16	11.38	5.72	10.72	115.9
4	110	7.29	12.39	7.50	12.37	7.54	11.50	5.93	10.94	112.7
5	112	7.57	12.57	7.73	12.39	7.77	11.53	6.07	11.07	110.7
6	115	8.13	12.84	8.07	12.43	8.09	11.58	6.27	11.28	107.8
7	118	8.70	13.11	8.38	12.46	8.38	11.64	6.50	11.53	105.1
8	121	9.40	13.24	8.69	12.50	8.66	11.69	6.74	11.78	102.5
9	124	10.03	13.08	8.98	12.53	8.93	11.75	7.01	12.03	100.0
10	127	10.56	12.93	9.26	12.57	9.19	11.81	7.29	12.28	97.6
11	130	11.00	12.78	9.53	12.60	9.44	11.86	7.60	12.52	95.4
12	133	11.34	12.64	9.80	12.65	9.67	11.91	7.98	12.76	93.2
13	136	11.64	12.50	10.06	12.69	9.91	11.97	8.36	12.85	91.2
14	140	12.03	12.32	10.40	12.75	10.22	12.04	8.80	12.97	88.6
15	143	12.31	12.19	10.66	12.79	10.44	12.09	9.11	13.06	86.7
16	147	12.64	12.03	11.01	12.85	10.73	12.15	9.50	13.17	84.3
17	150	12.95	11.91	11.30	12.89	10.92	12.21	9.80	13.26	82.7
18	154	13.15	11.81	11.65	12.95	11.16	12.32	10.22	13.31	80.5
19	158	13.40	11.72	12.06	13.00	11.47	12.44	10.57	13.33	78.5
20	162	13.68	11.63	12.47	12.99	11.80	12.56	10.88	13.36	76.5
21	166	13.95	11.54	12.86	12.91	12.15	12.68	11.15	13.38	74.7
22	170	14.23	11.46	13.20	12.84	12.53	12.79	11.36	13.40	72.9
23	174	14.45	11.37	13.51	12.76	12.94	12.82	11.56	13.58	71.3
24	178	14.68	11.29	13.82	12.69	13.32	12.80	11.87	13.87	69.7
25	182	14.96	11.22	14.11	12.62	13.68	12.78	12.34	14.16	68.1
26	187	15.25	11.12	14.48	12.54	14.11	12.71	13.00	14.18	66.3
27	191	15.54	11.05	14.77	12.47	14.43	12.65	13.48	14.11	64.9
28	196	15.84	10.96	15.11	12.34	14.80	12.55	13.96	14.02	63.3
29	201	16.23	10.84	15.43	12.21	15.15	12.45	14.39	13.92	61.7
30	206	16.58	10.57	15.73	12.09	15.48	12.36	14.79	13.83	60.2
31	211	16.89	10.31	16.04	11.97	15.82	12.26	15.18	13.73	58.8
32	216	17.07	10.07	16.31	11.82	16.13	12.13	15.57	13.61	57.4
33	221	17.29	9.84	16.57	11.67	16.41	11.99	15.90	13.47	56.1
34	227	17.48	9.57	16.87	11.50	16.72	11.83	16.27	13.31	54.6
35	232	17.63	9.37	17.10	11.36	16.96	11.70	16.56	13.19	53.4
36	238	17.78	9.13	17.37	11.21	17.23	11.56	16.89	13.04	52.1
37	244	17.91	8.90	17.62	11.03	17.49	11.41	17.19	12.90	50.8
38	250	18.03	8.68	17.86	10.85	17.73	11.27	17.49	12.76	49.6
39	256	18.14	8.47	18.08	10.68	17.97	11.14	17.77	12.63	48.4
40	262	18.25	8.28	18.28	10.51	18.20	11.01	18.05	12.50	47.3
41	269	18.34	8.06	18.51	10.32	18.46	10.87	18.37	12.36	46.1
42	275	18.44	7.88	18.69	10.15	18.69	10.75	18.66	12.24	45.1
43	282	18.45	7.71	18.89	9.96	18.94	10.57	18.97	12.04	44.0
44	289	18.50	7.56	19.08	9.77	19.17	10.38	19.25	11.83	42.9
45	296	18.57	7.42	19.25	9.59	19.37	10.19	19.50	11.63	41.9
46	303	18.63	7.28	19.42	9.41	19.55	10.02	19.73	11.44	40.9
47	311	18.75	7.13	19.59	9.20	19.74	9.83	19.97	11.23	39.9
48	318	18.79	7.00	19.73	9.03	19.90	9.67	20.16	11.05	39.0
49	326	18.82	6.86	19.87	8.84	20.07	9.49	20.37	10.86	38.0
50	334	18.88	6.73	20.01	8.65	20.22	9.32	20.55	10.67	37.1
51	342	18.93	6.60	20.13	8.46	20.37	9.16	20.73	10.49	36.3
52	351	18.98	6.47	20.26	8.26	20.52	8.98	20.93	10.30	35.3
53	359	19.02	6.35	20.36	8.09	20.65	8.83	21.09	10.13	34.5
54	368	19.07	6.23	20.47	7.90	20.79	8.67	21.27	9.95	33.7
55	377	19.10	6.11	20.56	7.71	20.93	8.52	21.44	9.78	32.9
56	386	19.14	5.99	20.65	7.54	21.06	8.37	21.61	9.62	32.1
57	396	19.23	5.87	20.74	7.35	21.22	8.19	21.81	9.43	31.3
58	406	19.19	5.77	20.81	7.16	21.35	8.00	21.98	9.21	30.5
59	415	19.21	5.68	20.87	7.01	21.45	7.83	22.12	9.02	29.9
60	426	19.25	5.57	20.93	6.82	21.56	7.64	22.26	8.79	29.1
61	436	19.28	5.48	20.98	6.65	21.65	7.47	22.37	8.60	28.4
62	447	19.31	5.39	21.03	6.48	21.74	7.29	22.49	8.40	27.7
63	458	19.38	5.28	21.07	6.31	21.82	7.11	22.60	8.19	27.1
64	469	19.37	5.18	21.10	6.15	21.89	6.94	22.69	8.00	26.4

N	E(eV)	Cu (29) Copper f_1	Cu (29) Copper f_2	Zn (30) Zinc f_1	Zn (30) Zinc f_2	Ga (31) Gallium f_1	Ga (31) Gallium f_2	Ge (32) Germanium f_1	Ge (32) Germanium f_2	λ(A)
65	480	19.38	5.07	21.12	6.00	21.95	6.77	22.77	7.81	25.83
66	492	19.39	4.97	21.14	5.81	22.00	6.60	22.85	7.61	25.20
67	504	19.44	4.86	21.15	5.63	22.05	6.43	22.92	7.43	24.60
68	516	19.43	4.77	21.15	5.46	22.09	6.28	22.98	7.25	24.03
69	529	19.45	4.65	21.15	5.29	22.13	6.11	23.04	7.07	23.44
70	542	19.42	4.52	21.14	5.14	22.16	5.94	23.10	6.88	22.87
71	555	19.47	4.39	21.12	5.00	22.18	5.78	23.15	6.71	22.34
72	569	19.39	4.26	21.09	4.85	22.18	5.61	23.18	6.52	21.79
73	583	19.34	4.12	21.05	4.71	22.18	5.45	23.20	6.34	21.27
74	597	19.25	3.97	21.01	4.58	22.16	5.31	23.22	6.18	20.77
75	612	19.16	3.83	20.96	4.45	22.14	5.16	23.23	6.01	20.26
76	627	19.05	3.70	20.89	4.32	22.12	5.02	23.24	5.84	19.77
77	642	18.99	3.56	20.82	4.20	22.09	4.89	23.24	5.68	19.31
78	658	18.76	3.42	20.73	4.06	22.04	4.73	23.22	5.50	18.84
79	674	18.63	3.28	20.64	3.93	21.98	4.59	23.19	5.33	18.39
80	690	18.36	3.17	20.53	3.83	21.91	4.48	23.14	5.20	17.97
81	707	18.16	3.07	20.40	3.74	21.84	4.37	23.10	5.07	17.54
82	725	17.73	3.04	20.25	3.63	21.76	4.25	23.05	4.92	17.10
83	742	17.45	3.02	20.10	3.54	21.68	4.13	23.00	4.79	16.71
84	760	17.13	2.99	19.91	3.44	21.58	4.01	22.94	4.65	16.31
85	779	16.94	2.95	19.70	3.35	21.46	3.90	22.86	4.51	15.92
86	798	16.35	2.83	19.46	3.24	21.33	3.77	22.77	4.37	15.54
87	818	15.76	2.72	19.16	3.13	21.17	3.65	22.66	4.24	15.16
88	838	14.96	2.61	18.83	3.03	20.98	3.53	22.54	4.11	14.79
89	858	14.20	2.51	18.45	2.93	20.77	3.42	22.40	3.98	14.45
90	879	12.47	2.42	17.98	2.83	20.52	3.31	22.24	3.85	14.10
91	901	9.51	2.33	17.38	2.74	20.22	3.20	22.05	3.73	13.76
92	923	2.02 L	2.25	16.68	2.65	19.89	3.10	21.84	3.61	13.43
93	945	5.01	18.03	15.84	2.58	19.49	3.00	21.61	3.50	13.12
94	968	12.97	17.24	13.08	2.51	19.01	2.90	21.33	3.39	12.81
95	992	16.02	16.46	10.03	2.44	18.37	2.81	20.99	3.28	12.50
96	1016	17.55	15.74	3.73 L	2.38	17.61	2.72	20.61	3.17	12.20
97	1041	18.72	15.03	10.53	17.00	16.58	2.64	20.16	3.08	11.91
98	1067	19.75	14.77	14.20	16.69	14.81	2.56	19.56	2.98	11.62
99	1093	20.60	14.53	16.23	16.40	9.52	2.48	18.83	2.88	11.34
100	1119	21.35	14.29	17.87	16.11	2.29 L	15.61	17.93	2.80	11.08
101	1147	22.07	14.04	19.30	15.82	8.52	15.37	16.57	2.71	10.81
102	1175	22.69	13.81	20.54	15.54	14.62	15.14	14.17	2.62	10.55
103	1204	23.39	13.57	21.78	15.26	18.35	14.90	6.62 L	2.54	10.30
104	1233	24.02	13.35	22.95	14.99	19.55	14.68	8.63	16.64	10.06
105	1263	24.69	13.05	23.82	14.65	20.48	14.46	15.91	16.37	9.82
106	1294	25.29	12.59	24.54	14.15	20.79	14.24	18.26	16.11	9.58
107	1326	25.78	12.14	25.20	13.66	21.92	15.42	20.23	15.85	9.35
108	1358	26.20	11.71	25.73	13.20	23.92	14.89	21.60	15.60	9.13
109	1392	26.55	11.29	26.24	12.74	24.86	14.37	22.80	15.34	8.91
110	1426	26.86	10.89	26.68	12.31	25.68	13.87	23.86	15.10	8.69
111	1460	27.13	10.51	27.06	11.90	26.33	13.40	24.80	14.86	8.49
112	1496	27.37	10.14	27.42	11.49	26.91	12.93	25.74	14.55	8.29
113	1533	27.61	9.77	27.74	11.09	27.41	12.48	26.60	14.07	8.09
114	1570	27.81	9.43	28.01	10.71	27.83	12.05	27.22	13.61	7.90
115	1609	27.99	9.08	28.28	10.33	28.23	11.63	27.81	13.15	7.71
116	1648	28.15	8.76	28.51	9.98	28.59	11.23	28.32	12.72	7.52
117	1688	28.29	8.45	28.71	9.64	28.89	10.84	28.76	12.31	7.34
118	1730	28.42	8.15	28.91	9.30	29.19	10.46	29.19	11.89	7.17
119	1772	28.55	7.85	29.07	8.96	29.45	10.09	29.56	11.48	7.00
120	1815	28.65	7.56	29.21	8.64	29.66	9.73	29.89	11.08	6.83
121	1860	28.74	7.27	29.35	8.32	29.87	9.37	30.19	10.68	6.67
122	1905	28.82	7.01	29.46	8.02	30.02	9.03	30.40	10.31	6.51
123	1952	28.88	6.74	29.56	7.73	30.18	8.70	30.63	9.94	6.35
124	2000	28.93	6.49	29.65	7.44	30.34	8.38	30.86	9.58	6.20
	$\frac{E\mu(E)}{f_2}$	661.8		643.3		603.2		579.4		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	63.55		65.38		69.72		72.59		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	As (33)		Se (34)		Br (35)		Kr (36)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	2.69	7.92	2.39	7.29	2.81	5.14	4.08	1.83	124.0
1	102	2.74	8.27	2.40	7.61	2.74	5.41	3.87	1.94	121.5
2	104	2.82	8.64	2.43	7.94	2.69	5.68	3.64	2.13	119.2
3	107	2.97	9.20	2.49	8.45	2.62	6.11	3.35	2.46	115.9
4	110	3.20	9.79	2.60	8.87	2.61	6.52	2.99	2.79	112.7
5	112	3.45	10.19	2.71	9.09	2.59	6.78	2.77	3.03	110.7
6	115	3.90	10.68	2.93	9.43	2.56	7.18	2.49	3.43	107.8
7	118	4.33	10.92	3.15	9.78	2.54	7.62	2.15	3.98	105.1
8	121	4.67	11.17	3.34	10.13	2.54	8.07	1.94	4.47	102.5
9	124	4.96	11.41	3.53	10.49	2.56	8.53	1.73	4.97	100.0
10	127	5.23	11.64	3.71	10.85	2.60	9.01	1.53	5.48	97.6
11	130	5.48	11.88	3.90	11.21	2.66	9.51	1.33	6.01	95.4
12	133	5.69	12.13	4.11	11.57	2.76	10.02	1.14	6.60	93.2
13	136	5.92	12.47	4.34	11.94	2.90	10.54	0.90	7.35	91.2
14	140	6.30	12.93	4.66	12.44	3.15	11.26	0.79	8.45	88.6
15	143	6.63	13.28	4.93	12.81	3.40	11.82	0.80	9.36	86.7
16	147	7.21	13.75	5.38	13.32	3.90	12.59	1.27	10.69	84.3
17	150	7.74	14.01	5.75	13.64	4.41	13.07	1.96	11.57	82.7
18	154	8.40	14.10	6.25	13.96	5.10	13.36	2.76	12.05	80.5
19	158	8.91	14.15	6.69	14.26	5.61	13.57	3.36	12.41	78.5
20	162	9.37	14.20	7.14	14.57	6.05	13.77	3.84	12.76	76.5
21	166	9.79	14.25	7.61	14.87	6.44	13.98	4.28	13.12	74.7
22	170	10.18	14.30	8.11	15.18	6.79	14.18	4.70	13.48	72.9
23	174	10.53	14.36	8.65	15.38	7.10	14.39	5.13	13.84	71.3
24	178	10.88	14.42	9.16	15.52	7.36	14.59	5.49	14.20	69.7
25	182	11.24	14.49	9.64	15.65	7.51	14.80	5.90	14.56	68.1
26	187	11.67	14.54	10.20	15.78	7.82	15.48	6.44	15.02	66.3
27	191	11.97	14.57	10.66	15.88	8.26	16.16	6.97	15.39	64.9
28	196	12.31	14.69	11.21	15.95	9.23	16.51	7.55	15.69	63.3
29	201	12.73	14.86	11.74	16.00	9.91	16.62	8.13	15.91	61.7
30	206	13.22	15.02	12.23	16.04	10.54	16.73	8.65	16.13	60.2
31	211	13.76	15.18	12.71	16.08	11.15	16.84	9.20	16.35	58.8
32	216	14.38	15.11	13.22	16.07	11.71	16.88	9.66	16.52	57.4
33	221	14.86	14.98	13.66	16.04	12.23	16.90	10.14	16.69	56.1
34	227	15.38	14.83	14.16	16.00	12.82	16.93	10.68	16.88	54.6
35	232	15.77	14.71	14.56	15.96	13.27	16.95	11.12	17.03	53.4
36	238	16.19	14.57	15.02	15.93	13.79	16.97	11.65	17.22	52.1
37	244	16.59	14.44	15.45	15.89	14.31	17.00	12.18	17.40	50.8
38	250	16.96	14.31	15.89	15.86	14.81	17.02	12.70	17.58	49.6
39	256	17.32	14.18	16.32	15.82	15.31	17.05	13.23	17.76	48.4
40	262	17.67	14.06	16.75	15.79	15.81	17.07	13.78	17.93	47.3
41	269	18.07	13.92	17.27	15.75	16.42	17.10	14.48	18.14	46.1
42	275	18.42	13.80	17.75	15.72	17.00	17.12	15.16	18.31	45.1
43	282	18.82	13.60	18.33	15.52	17.67	16.95	15.99	18.24	44.0
44	289	19.17	13.38	18.80	15.28	18.25	16.71	16.63	18.08	42.9
45	296	19.48	13.17	19.21	15.04	18.75	16.48	17.22	17.92	41.9
46	303	19.76	12.97	19.58	14.82	19.18	16.26	17.76	17.77	40.9
47	311	20.05	12.75	19.97	14.57	19.65	16.01	18.39	17.60	39.9
48	318	20.30	12.56	20.28	14.36	20.02	15.80	18.76	17.46	39.0
49	326	20.57	12.35	20.62	14.13	20.41	15.58	19.26	17.30	38.0
50	334	20.81	12.16	20.92	13.91	20.78	15.36	19.72	17.15	37.1
51	342	21.04	11.97	21.21	13.69	21.13	15.15	20.16	17.00	36.3
52	351	21.29	11.76	21.52	13.46	21.51	14.92	20.64	16.84	35.3
53	359	21.50	11.59	21.79	13.27	21.82	14.73	21.06	16.71	34.5
54	368	21.73	11.40	22.07	13.06	22.16	14.52	21.52	16.56	33.7
55	377	21.95	11.22	22.34	12.85	22.50	14.31	21.98	16.41	32.9
56	386	22.17	11.04	22.62	12.66	22.83	14.12	22.45	16.27	32.1
57	396	22.43	10.84	22.94	12.43	23.24	13.89	23.09	16.06	31.3
58	406	22.65	10.59	23.21	12.15	23.57	13.58	23.51	15.72	30.5
59	415	22.83	10.37	23.43	11.90	23.85	13.32	23.90	15.42	29.9
60	426	23.02	10.12	23.67	11.62	24.14	13.01	24.31	15.07	29.1
61	436	23.18	9.90	23.86	11.38	24.38	12.74	24.63	14.77	28.4
62	447	23.35	9.67	24.07	11.12	24.63	12.46	25.02	14.45	27.7
63	458	23.49	9.45	24.25	10.86	24.87	12.18	25.30	14.13	27.1
64	469	23.62	9.22	24.42	10.61	25.08	11.91	25.57	13.82	26.4

N	E(eV)	As (33) Arsenic f_1	As (33) Arsenic f_2	Se (34) Selenium f_1	Se (34) Selenium f_2	Br (35) Bromine f_1	Br (35) Bromine f_2	Kr (36) Krypton f_1	Kr (36) Krypton f_2	λ(A)
65	480	23.74	9.01	24.57	10.37	25.27	11.64	25.83	13.52	25.83
66	492	23.85	8.79	24.72	10.12	25.45	11.37	26.09	13.21	25.20
67	504	23.95	8.58	24.85	9.88	25.62	11.11	26.32	12.92	24.60
68	516	24.05	8.37	24.98	9.65	25.78	10.86	26.59	12.63	24.03
69	529	24.14	8.16	25.11	9.41	25.95	10.59	26.83	12.34	23.44
70	542	24.23	7.95	25.23	9.18	26.10	10.34	26.97	12.05	22.87
71	555	24.31	7.75	25.34	8.95	26.25	10.09	27.25	11.77	22.34
72	569	24.38	7.53	25.44	8.71	26.38	9.82	27.42	11.46	21.79
73	583	24.43	7.33	25.52	8.47	26.49	9.56	27.54	11.17	21.27
74	597	24.47	7.13	25.59	8.25	26.59	9.32	27.69	10.88	20.77
75	612	24.51	6.94	25.66	8.03	26.69	9.07	27.83	10.60	20.26
76	627	24.55	6.75	25.73	7.82	26.78	8.84	28.02	10.32	19.77
77	642	24.58	6.56	25.79	7.60	26.88	8.61	28.13	10.05	19.31
78	658	24.59	6.36	25.83	7.36	26.95	8.34	28.23	9.73	18.84
79	674	24.59	6.16	25.85	7.13	26.99	8.09	28.39	9.43	18.39
80	690	24.56	6.01	25.85	6.96	27.02	7.90	28.37	9.20	17.97
81	707	24.56	5.86	25.87	6.79	27.07	7.71	28.51	8.98	17.54
82	725	24.54	5.68	25.89	6.58	27.12	7.48	28.52	8.71	17.10
83	742	24.52	5.53	25.89	6.40	27.15	7.27	28.58	8.47	16.71
84	760	24.49	5.37	25.89	6.22	27.18	7.06	28.64	8.23	16.31
85	779	24.46	5.21	25.88	6.03	27.20	6.86	28.77	7.99	15.92
86	798	24.41	5.05	25.86	5.85	27.21	6.65	28.72	7.75	15.54
87	818	24.35	4.90	25.83	5.67	27.20	6.44	28.75	7.51	15.16
88	838	24.27	4.75	25.79	5.50	27.19	6.25	28.76	7.29	14.79
89	858	24.19	4.61	25.74	5.34	27.17	6.06	28.84	7.08	14.45
90	879	24.09	4.46	25.68	5.17	27.14	5.88	28.77	6.86	14.10
91	901	23.97	4.32	25.60	5.01	27.09	5.70	28.76	6.65	13.76
92	923	23.84	4.19	25.52	4.86	27.05	5.53	28.82	6.45	13.43
93	945	23.70	4.06	25.43	4.71	26.99	5.36	28.72	6.26	13.12
94	968	23.53	3.93	25.33	4.56	26.92	5.20	28.69	6.06	12.81
95	992	23.34	3.80	25.20	4.41	26.85	5.04	28.64	5.87	12.50
96	1016	23.12	3.69	25.06	4.27	26.76	4.88	28.69	5.69	12.20
97	1041	22.87	3.57	24.90	4.13	26.67	4.73	28.65	5.50	11.91
98	1067	22.57	3.45	24.71	3.99	26.55	4.57	28.47	5.32	11.62
99	1093	22.23	3.34	24.50	3.86	26.41	4.42	28.36	5.15	11.34
100	1119	21.84	3.24	24.26	3.74	26.27	4.28	28.26	4.99	11.08
101	1147	21.34	3.13	23.98	3.61	26.09	4.14	28.14	4.82	10.81
102	1175	20.73	3.03	23.66	3.49	25.90	4.00	28.01	4.66	10.55
103	1204	19.92	2.93	23.27	3.38	25.67	3.87	27.95	4.51	10.30
104	1233	18.95	2.84	22.83	3.27	25.42	3.74	27.73	4.37	10.06
105	1263	17.35	2.75	22.28	3.16	25.13	3.62	27.59	4.22	9.82
106	1294	12.20	2.66	21.54	3.06	24.78	3.50	27.29	4.08	9.58
107	1326	3.75 L	16.41	20.56	2.96	24.38	3.38	27.04	3.94	9.35
108	1358	9.44	15.94	19.33	2.86	23.88	3.27	26.77	3.81	9.13
109	1392	15.44	15.47	16.62	2.77	23.24	3.16	26.41	3.68	8.91
110	1426	21.00	15.03	8.52 L	2.68	22.45	3.06	26.01	3.56	8.69
111	1460	22.06	14.61	11.68	16.04	21.37	2.96	25.59	3.44	8.49
112	1496	22.86	14.19	19.14	15.55	19.60	2.86	25.15	3.32	8.29
113	1533	22.67	15.68	20.20	15.08	14.51	2.79	24.12	3.20	8.09
114	1570	24.51	15.18	21.27	14.64	12.92 L	11.81	23.03	3.09	7.90
115	1609	26.27	14.68	22.39	14.19	16.36	15.60	21.38	2.97	7.71
116	1648	27.11	14.21	23.52	13.77	18.89	15.13	15.37	2.87	7.52
117	1688	27.90	13.76	25.32	15.17	21.47	14.68	12.54 L	11.50	7.34
118	1730	28.56	13.30	27.09	14.69	24.19	14.22	20.76	15.02	7.17
119	1772	29.11	12.85	28.06	14.21	24.65	13.79	22.72	14.57	7.00
120	1815	29.60	12.41	28.88	13.74	25.62	15.37	25.66	14.12	6.83
121	1860	30.04	11.97	29.51	13.28	27.93	14.85	26.31	13.68	6.67
122	1905	30.43	11.56	30.10	12.84	28.69	14.36	26.99	13.27	6.51
123	1952	30.76	11.16	30.56	12.41	29.48	13.87	28.07	14.61	6.35
124	2000	31.07	10.77	31.00	11.99	30.29	13.40	29.17	14.15	6.20
	$\frac{E\mu(E)}{f_2}$	561.3		532.6		526.3		501.9		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	74.92		78.96		79.91		83.80		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Rb (37) f_1	Rb (37) f_2	Sr (38) f_1	Sr (38) f_2	Y (39) f_1	Y (39) f_2	Zr (40) f_1	Zr (40) f_2	λ(A)
0	100	5.67	1.00	7.74	1.12	9.86	2.75	13.43	2.59	124.0
1	102	5.44	1.03	7.58	1.17	9.79	2.75	13.39	2.58	121.5
2	104	5.17	1.05	7.44	1.22	9.72	2.74	13.35	2.57	119.2
3	107	4.73	1.09	7.23	1.29	9.61	2.73	13.30	2.56	115.9
4	110	4.12 M	1.16	7.01	1.37	9.50	2.72	13.23	2.55	112.7
5	112	3.68	1.38	6.87	1.42	9.41	2.71	13.19	2.54	110.7
6	115	3.05	1.78	6.64	1.50	9.26	2.70	13.10	2.54	107.8
7	118	2.47	2.28	6.40	1.59	9.09	2.70	13.03	2.56	105.1
8	121	1.90	2.90	6.15	1.67	8.90	2.75	12.96	2.58	102.5
9	124	1.41	3.67	5.87	1.76	8.74	2.81	12.90	2.61	100.0
10	127	1.04	4.62	5.56	1.85	8.57	2.86	12.83	2.63	97.6
11	130	0.82	5.79	5.20	1.94	8.38	2.91	12.77	2.65	95.4
12	133	1.32	7.13	4.73 M	2.12	8.16	2.97	12.70	2.67	93.2
13	136	1.86	7.45	4.31	2.44	7.90	3.06	12.62	2.69	91.2
14	140	2.29	7.89	3.80	2.94	7.57	3.29	12.52	2.72	88.6
15	143	2.46	8.23	3.45	3.37	7.35	3.47	12.44	2.74	86.7
16	147	2.66	8.69	3.07	4.02	7.05	3.72	12.32	2.77	84.3
17	150	2.79	9.03	2.88	4.55	6.79	3.91	12.22	2.79	82.7
18	154	2.92	9.50	2.70	5.14	6.44 M	4.32	12.08	2.82	80.5
19	158	3.06	10.00	2.48	5.72	6.16	4.83	11.93	2.85	78.5
20	162	3.20	10.51	2.27	6.34	6.03	5.40	11.75	2.89	76.5
21	166	3.36	11.03	2.07	7.02	6.03	6.00	11.56	2.92	74.7
22	170	3.54	11.56	1.91	7.75	6.10	6.32	11.33	2.95	72.9
23	174	3.75	12.10	1.80	8.51	6.10	6.65	11.05	3.02	71.3
24	178	3.98	12.63	1.74	9.30	6.07	6.99	10.77 M	3.14	69.7
25	182	4.23	13.18	1.70	10.15	6.04	7.34	10.48	3.25	68.1
26	187	4.63	13.92	1.79	11.38	6.00	7.79	10.06	3.39	66.3
27	191	4.98	14.53	2.24	12.47	5.97	8.16	9.56	3.51	64.9
28	196	5.75	15.04	2.95	13.35	5.95	8.63	8.85	4.02	63.3
29	201	6.30	15.42	3.62	13.99	5.94	9.12	8.26	4.87	61.7
30	206	6.82	15.81	4.17	14.64	5.94	9.62	7.97	5.88	60.2
31	211	7.33	16.19	4.81	15.30	5.96	10.14	8.16	7.06	58.8
32	216	7.85	16.50	5.45	15.75	6.01	10.67	8.52	7.62	57.4
33	221	8.33	16.80	6.03	16.12	6.07	11.22	8.82	8.00	56.1
34	227	8.89	17.15	6.64	16.58	6.17	11.89	8.99	8.47	54.6
35	232	9.34	17.44	7.13	16.96	6.29	12.47	9.11	8.88	53.4
36	238	9.89	17.78	7.71	17.41	6.47	13.19	9.24	9.38	52.1
37	244	10.45	18.13	8.28	17.86	6.70	13.92	9.37	9.89	50.8
38	250	11.02	18.47	8.88	18.32	7.00	14.68	9.53	10.42	49.6
39	256	11.62	18.81	9.50	18.78	7.35	15.46	9.70	10.96	48.4
40	262	12.27	19.15	10.14	19.23	7.77	16.27	9.89	11.52	47.3
41	269	13.12	19.54	11.02	19.76	8.51	17.23	10.19	12.19	46.1
42	275	13.96	19.88	11.96	20.22	9.42	18.08	10.52	12.78	45.1
43	282	15.00	19.85	13.09	20.30	10.60	18.44	10.98	13.35	44.0
44	289	15.87	19.67	14.02	20.21	11.57	18.53	11.45	13.88	42.9
45	296	16.61	19.49	14.79	20.11	12.31	18.63	12.01	14.42	41.9
46	303	17.24	19.32	15.49	20.02	12.99	18.72	12.63	14.92	40.9
47	311	17.90	19.13	16.23	19.92	13.69	18.82	13.37	15.15	39.9
48	318	18.44	18.97	16.81	19.84	14.26	18.91	13.87	15.36	39.0
49	326	19.01	18.79	17.44	19.74	14.89	19.01	14.40	15.59	38.0
50	334	19.55	18.62	18.05	19.65	15.49	19.11	14.92	15.81	37.1
51	342	20.06	18.45	18.64	19.56	16.06	19.21	15.42	16.04	36.3
52	351	20.61	18.27	19.26	19.46	16.68	19.31	15.97	16.29	35.3
53	359	21.07	18.11	19.80	19.38	17.22	19.40	16.45	16.51	34.5
54	368	21.58	17.94	20.40	19.29	17.82	19.50	17.01	16.75	33.7
55	377	22.08	17.78	21.00	19.20	18.40	19.60	17.60	17.00	32.9
56	386	22.60	17.62	21.66	19.11	18.79	19.70	18.30	17.24	32.1
57	396	23.20	17.40	22.44	18.94	19.20	20.92	19.16	17.35	31.3
58	406	23.74	17.06	23.10	18.57	20.89	20.53	19.87	17.23	30.5
59	415	24.17	16.76	23.58	18.26	21.76	20.20	20.38	17.12	29.9
60	426	24.61	16.41	24.13	17.89	22.66	19.82	20.96	17.00	29.1
61	436	24.99	16.10	24.59	17.58	23.35	19.48	21.43	16.89	28.4
62	447	25.38	15.78	25.05	17.24	24.02	19.12	21.87	16.77	27.7
63	458	25.76	15.46	25.48	16.90	24.62	18.76	22.27	16.73	27.1
64	469	26.08	15.13	25.88	16.56	25.16	18.41	22.69	16.74	26.4

N	E(eV)	Rb (37) Rubidium f_1	Rb (37) Rubidium f_2	Sr (38) Strontium f_1	Sr (38) Strontium f_2	Y (39) Yttrium f_1	Y (39) Yttrium f_2	Zr (40) Zirconium f_1	Zr (40) Zirconium f_2	λ(A)
65	480	26.38	14.82	26.24	16.24	25.66	18.06	23.13	16.76	25.83
66	492	26.68	14.49	26.60	15.90	26.14	17.70	23.63	16.78	25.20
67	504	26.96	14.18	26.93	15.57	26.59	17.36	24.15	16.80	24.60
68	516	27.22	13.88	27.25	15.26	27.02	17.03	24.74	16.81	24.03
69	529	27.50	13.57	27.58	14.93	27.46	16.67	25.48	16.73	23.44
70	542	27.76	13.24	27.87	14.59	27.86	16.31	26.08	16.42	22.87
71	555	28.00	12.93	28.16	14.27	28.24	15.95	26.61	16.12	22.34
72	569	28.21	12.58	28.44	13.92	28.60	15.56	27.08	15.81	21.79
73	583	28.40	12.26	28.68	13.59	28.92	15.19	27.50	15.52	21.27
74	597	28.57	11.96	28.90	13.27	29.21	14.84	27.88	15.23	20.77
75	612	28.74	11.66	29.12	12.94	29.50	14.47	28.26	14.94	20.26
76	627	28.91	11.37	29.33	12.63	29.78	14.13	28.60	14.67	19.77
77	642	29.07	11.07	29.54	12.32	30.05	13.78	28.93	14.40	19.31
78	658	29.20	10.75	29.72	11.97	30.28	13.38	29.24	14.13	18.84
79	674	29.30	10.44	29.85	11.63	30.46	13.01	29.54	13.87	18.39
80	690	29.38	10.20	29.97	11.37	30.61	12.72	29.82	13.62	17.97
81	707	29.50	9.96	30.12	11.11	30.81	12.43	30.10	13.37	17.54
82	725	29.61	9.68	30.29	10.80	31.01	12.08	30.39	13.11	17.10
83	742	29.71	9.42	30.41	10.51	31.18	11.77	30.65	12.87	16.71
84	760	29.79	9.17	30.52	10.22	31.33	11.46	30.94	12.64	16.31
85	779	29.87	8.90	30.65	9.93	31.48	11.14	31.25	12.39	15.92
86	798	29.93	8.64	30.72	9.64	31.61	10.82	31.55	12.04	15.54
87	818	29.99	8.38	30.80	9.36	31.73	10.51	31.79	11.69	15.16
88	838	30.03	8.13	30.87	9.09	31.83	10.21	31.99	11.36	14.79
89	858	30.07	7.90	30.93	8.83	31.92	9.92	32.16	11.04	14.45
90	879	30.10	7.66	30.97	8.57	32.01	9.63	32.33	10.72	14.10
91	901	30.11	7.42	31.01	8.31	32.07	9.35	32.47	10.40	13.76
92	923	30.13	7.20	31.05	8.07	32.14	9.08	32.60	10.10	13.43
93	945	30.13	6.98	31.08	7.83	32.20	8.81	32.72	9.81	13.12
94	968	30.12	6.76	31.09	7.59	32.24	8.55	32.82	9.52	12.81
95	992	30.09	6.55	31.10	7.36	32.28	8.28	32.90	9.24	12.50
96	1016	30.07	6.35	31.09	7.13	32.30	8.03	32.98	8.96	12.20
97	1041	30.04	6.15	31.09	6.91	32.33	7.79	33.05	8.69	11.91
98	1067	29.99	5.95	31.07	6.69	32.33	7.53	33.11	8.42	11.62
99	1093	29.94	5.77	31.04	6.48	32.33	7.30	33.15	8.15	11.34
100	1119	29.88	5.59	31.00	6.28	32.32	7.07	33.18	7.91	11.08
101	1147	29.80	5.41	30.96	6.08	32.30	6.84	33.20	7.65	10.81
102	1175	29.72	5.24	30.91	5.89	32.28	6.63	33.22	7.41	10.55
103	1204	29.63	5.07	30.83	5.70	32.23	6.42	33.21	7.18	10.30
104	1233	29.52	4.91	30.76	5.52	32.19	6.22	33.21	6.96	10.06
105	1263	29.41	4.75	30.68	5.35	32.14	6.02	33.20	6.74	9.82
106	1294	29.27	4.59	30.59	5.17	32.07	5.82	33.17	6.52	9.58
107	1326	29.12	4.44	30.48	5.00	32.00	5.63	33.14	6.30	9.35
108	1358	28.95	4.29	30.35	4.83	31.91	5.45	33.09	6.10	9.13
109	1392	28.74	4.14	30.21	4.67	31.81	5.27	33.03	5.90	8.91
110	1426	28.52	4.00	30.04	4.51	31.70	5.09	32.96	5.70	8.69
111	1460	28.27	3.87	29.87	4.36	31.58	4.93	32.88	5.52	8.49
112	1496	27.97	3.74	29.66	4.22	31.44	4.77	32.79	5.34	8.29
113	1533	27.61	3.59	29.42	4.08	31.28	4.60	32.68	5.16	8.09
114	1570	27.20	3.46	29.15	3.94	31.11	4.45	32.56	4.99	7.90
115	1609	26.63	3.32	28.84	3.81	30.90	4.29	32.42	4.82	7.71
116	1648	25.92	3.20	28.47	3.69	30.66	4.14	32.26	4.67	7.52
117	1688	25.02	3.08	28.02	3.56	30.39	4.00	32.09	4.51	7.34
118	1730	23.61	2.96	27.49	3.44	30.08	3.86	31.89	4.36	7.17
119	1772	19.45	2.84	26.81	3.34	29.71	3.73	31.65	4.21	7.00
120	1815	13.87 L	11.43	25.83	3.24	29.26	3.61	31.38	4.07	6.83
121	1860	16.63	10.74	25.19	3.14	28.69	3.48	31.00	3.93	6.67
122	1905	19.38	14.49	25.03	3.04	27.98	3.36	30.53	3.80	6.51
123	1952	22.26	14.04	24.86 L	11.60	26.41	3.25	30.03	3.67	6.35
124	2000	25.20	13.61	24.69	10.95	24.79	3.14	29.52	3.55	6.20
	$\frac{E_H(E)}{f_2}$	492.1		480.0		473.1		461.1		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	85.47		87.62		88.91		91.22		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Nb (41) f_1	Nb (41) f_2	Mo (42) f_1	Mo (42) f_2	Tc (43) f_1	Tc (43) f_2	Ru (44) f_1	Ru (44) f_2	λ(A)
0	100	14.84	2.73	15.43	2.01	15.78	1.80	18.51	1.38	124.0
1	102	14.79	2.68	15.33	2.00	15.67	1.82	18.29	1.25	121.5
2	104	14.74	2.64	15.25	1.99	15.59	1.83	18.02	1.13	119.2
3	107	14.66	2.58	15.13	1.98	15.47	1.85	17.65	1.13	115.9
4	110	14.57	2.52	15.03	1.97	15.38	1.87	17.37	1.18	112.7
5	112	14.49	2.48	14.95	1.96	15.32	1.88	17.23	1.21	110.7
6	115	14.38	2.44	14.84	1.96	15.23	1.90	17.03	1.26	107.8
7	118	14.27	2.45	14.74	1.98	15.15	1.92	16.86	1.31	105.1
8	121	14.18	2.46	14.65	2.00	15.08	1.94	16.71	1.36	102.5
9	124	14.10	2.47	14.57	2.02	15.02	1.96	16.58	1.41	100.0
10	127	14.03	2.48	14.50	2.04	14.96	1.98	16.46	1.46	97.6
11	130	13.96	2.49	14.43	2.06	14.90	2.00	16.36	1.51	95.4
12	133	13.89	2.50	14.35	2.08	14.84	2.02	16.26	1.56	93.2
13	136	13.82	2.51	14.28	2.09	14.78	2.04	16.16	1.62	91.2
14	140	13.72	2.52	14.18	2.12	14.70	2.06	16.05	1.69	88.6
15	143	13.65	2.53	14.12	2.14	14.64	2.08	15.97	1.74	86.7
16	147	13.55	2.54	14.02	2.16	14.57	2.10	15.88	1.81	84.3
17	150	13.46	2.55	13.95	2.18	14.51	2.12	15.81	1.87	82.7
18	154	13.34	2.57	13.85	2.20	14.44	2.14	15.73	1.94	80.5
19	158	13.22	2.61	13.74	2.21	14.36	2.16	15.67	2.01	78.5
20	162	13.11	2.64	13.63	2.23	14.28	2.19	15.60	2.07	76.5
21	166	12.99	2.67	13.50	2.24	14.19	2.21	15.52	2.12	74.7
22	170	12.88	2.70	13.37	2.26	14.11	2.23	15.45	2.18	72.9
23	174	12.76	2.70	13.22	2.28	14.02	2.25	15.38	2.23	71.3
24	178	12.61	2.68	13.07	2.31	13.92	2.27	15.31	2.29	69.7
25	182	12.44	2.66	12.91	2.34	13.82	2.29	15.24	2.34	68.1
26	187	12.17	2.64	12.70	2.37	13.68	2.32	15.15	2.41	66.3
27	191	11.87	2.62	12.51	2.40	13.57	2.34	15.08	2.47	64.9
28	196	11.45	2.72	12.25	2.43	13.42	2.36	14.98	2.54	63.3
29	201	11.04	2.90	11.96	2.45	13.26	2.39	14.89	2.61	61.7
30	206	10.66 M	3.10	11.60	2.48	13.08	2.41	14.79	2.68	60.2
31	211	10.22	3.30	11.11	2.51	12.88	2.43	14.69	2.74	58.8
32	216	9.77	3.65	10.59	2.77	12.67	2.46	14.59	2.81	57.4
33	221	9.36	4.07	10.11	3.13	12.43	2.48	14.48	2.88	56.1
34	227	8.92	4.62	9.60 M	3.61	12.08	2.51	14.35	2.97	54.6
35	232	8.58	5.12	9.21	4.05	11.72	2.53	14.23	3.04	53.4
36	238	8.21	5.78	8.77	4.64	11.22	2.71	14.09	3.12	52.1
37	244	7.88	6.50	8.36	5.30	10.77	3.01	13.93	3.21	50.8
38	250	7.61	7.30	8.01	6.03	10.36	3.34	13.76	3.29	49.6
39	256	7.40	8.16	7.70	6.83	9.98 M	3.70	13.59	3.38	48.4
40	262	7.25	9.11	7.44	7.73	9.61	4.08	13.40	3.46	47.3
41	269	7.27	10.32	7.33	8.89	9.19	4.57	13.15	3.56	46.1
42	275	7.52	11.46	7.43	10.00	8.85	5.02	12.92	3.65	45.1
43	282	8.02	12.50	7.77	11.07	8.47	5.59	12.60 M	3.75	44.0
44	289	8.53	13.44	8.14	12.07	8.10	6.20	12.24	3.84	42.9
45	296	9.27	14.42	8.75	13.14	7.78	6.85	11.72	3.94	41.9
46	303	10.15	15.34	9.54	14.15	7.46	7.55	11.18	4.23	40.9
47	311	11.25	15.64	10.57	14.51	7.10	8.41	10.58	4.72	39.9
48	318	11.91	15.90	11.17	14.81	6.85	9.22	10.13	5.18	39.0
49	326	12.59	16.19	11.77	15.17	6.63	10.22	9.65	5.74	38.0
50	334	13.22	16.48	12.32	15.52	6.46	11.29	9.21	6.35	37.1
51	342	13.81	16.77	12.85	15.87	6.38	12.45	8.80	7.01	36.3
52	351	14.46	17.10	13.42	16.26	6.46	13.81	8.37	7.81	35.3
53	359	15.03	17.38	13.93	16.61	6.62	15.05	8.03	8.58	34.5
54	368	15.69	17.70	14.52	17.01	6.92	16.55	7.69	9.51	33.7
55	377	16.37	18.02	15.14	17.40	7.47	18.15	7.42	10.51	32.9
56	386	17.19	18.33	15.89	17.79	8.56	19.86	7.24	11.60	32.1
57	396	18.20	18.49	16.81	18.04	10.24	21.59	7.14	12.90	31.3
58	406	19.03	18.36	17.59	18.00	12.05	21.92	7.19	14.31	30.5
59	415	19.62	18.25	18.12	17.97	13.20	22.22	7.47	15.68	29.9
60	426	20.28	18.12	18.70	17.93	14.50	22.58	8.15	17.48	29.1
61	436	20.82	18.00	19.15	17.90	15.64	22.91	9.29	19.26	28.4
62	447	21.35	17.87	19.52	17.86	16.93	23.27	11.75	21.36	27.7
63	458	21.82	17.81	19.79	18.03	18.26	23.34	13.65	22.61	27.1
64	469	22.29	17.80	20.16	18.36	19.42	23.17	14.76	22.98	26.4

N	E(eV)	Nb (41) Niobium f_1	Nb (41) Niobium f_2	Mo (42) Molybdenum f_1	Mo (42) Molybdenum f_2	Tc (43) Technetium f_1	Tc (43) Technetium f_2	Ru (44) Ruthenium f_1	Ru (44) Ruthenium f_2	λ(A)
65	480	22.78	17.79	20.61	18.69	20.41	23.00	15.88	23.35	25.83
66	492	23.30	17.77	21.23	19.05	21.32	22.82	17.07	23.74	25.20
67	504	23.84	17.76	21.92	19.41	22.14	22.65	18.27	24.14	24.60
68	516	24.43	17.75	22.78	19.77	22.87	22.48	19.61	24.53	24.03
69	529	25.12	17.66	23.95	19.93	23.52	22.43	21.30	24.67	23.44
70	542	25.71	17.40	24.89	19.60	24.39	22.63	22.64	24.23	22.87
71	555	26.25	17.15	25.71	19.28	25.45	22.83	23.81	23.81	22.34
72	569	26.74	16.89	26.40	18.96	26.73	22.34	24.71	23.33	21.79
73	583	27.18	16.64	27.01	18.64	27.61	21.84	25.44	23.08	21.27
74	597	27.59	16.40	27.56	18.34	28.34	21.36	26.21	22.91	20.77
75	612	28.01	16.16	28.10	18.03	29.06	20.88	27.08	22.74	20.26
76	627	28.40	15.92	28.61	17.73	29.71	20.42	27.97	22.58	19.77
77	642	28.77	15.69	29.06	17.45	30.32	19.96	28.97	22.29	19.31
78	658	29.13	15.46	29.51	17.16	30.85	19.44	29.84	21.72	18.84
79	674	29.49	15.24	29.95	16.87	31.32	18.94	30.54	21.17	18.39
80	690	29.83	15.02	30.35	16.60	31.71	18.57	31.13	20.75	17.97
81	707	30.17	14.80	30.75	16.33	32.18	18.20	31.76	20.33	17.54
82	725	30.53	14.58	31.17	16.05	32.64	17.73	32.38	19.81	17.10
83	742	30.87	14.37	31.55	15.80	33.03	17.30	32.90	19.34	16.71
84	760	31.24	14.16	31.96	15.54	33.39	16.88	33.39	18.86	16.31
85	779	31.66	13.94	32.42	15.26	33.76	16.44	33.87	18.38	15.92
86	798	32.07	13.55	32.85	14.84	34.08	16.01	34.29	17.89	15.54
87	818	32.40	13.16	33.21	14.42	34.39	15.58	34.69	17.40	15.16
88	838	32.67	12.79	33.50	14.02	34.66	15.18	35.05	16.93	14.79
89	858	32.91	12.44	33.79	13.64	34.92	14.78	35.38	16.49	14.45
90	879	33.13	12.08	34.02	13.25	35.17	14.38	35.69	16.04	14.10
91	901	33.32	11.73	34.25	12.87	35.41	13.98	35.98	15.60	13.76
92	923	33.50	11.39	34.45	12.51	35.63	13.60	36.26	15.18	13.43
93	945	33.65	11.06	34.63	12.15	35.82	13.23	36.50	14.77	13.12
94	968	33.79	10.74	34.80	11.80	36.01	12.84	36.74	14.35	12.81
95	992	33.92	10.41	34.95	11.46	36.17	12.46	36.96	13.95	12.50
96	1016	34.04	10.11	35.10	11.12	36.33	12.10	37.17	13.55	12.20
97	1041	34.15	9.80	35.24	10.79	36.48	11.73	37.37	13.14	11.91
98	1067	34.23	9.48	35.34	10.45	36.59	11.35	37.54	12.72	11.62
99	1093	34.30	9.19	35.44	10.12	36.69	11.00	37.69	12.33	11.34
100	1119	34.36	8.91	35.51	9.82	36.77	10.67	37.81	11.96	11.08
101	1147	34.41	8.62	35.58	9.50	36.85	10.33	37.92	11.58	10.81
102	1175	34.45	8.35	35.65	9.21	36.93	10.01	38.05	11.22	10.55
103	1204	34.48	8.09	35.69	8.92	36.96	9.70	38.11	10.87	10.30
104	1233	34.50	7.84	35.74	8.65	37.00	9.40	38.19	10.53	10.06
105	1263	34.51	7.59	35.77	8.38	37.04	9.11	38.25	10.21	9.82
106	1294	34.51	7.34	35.79	8.11	37.06	8.83	38.30	9.89	9.58
107	1326	34.50	7.10	35.80	7.84	37.08	8.55	38.35	9.58	9.35
108	1358	34.48	6.87	35.80	7.59	37.09	8.29	38.39	9.29	9.13
109	1392	34.45	6.64	35.79	7.34	37.09	8.03	38.42	9.00	8.91
110	1426	34.41	6.43	35.77	7.10	37.08	7.78	38.45	8.72	8.69
111	1460	34.37	6.22	35.75	6.88	37.08	7.54	38.48	8.46	8.49
112	1496	34.32	6.01	35.71	6.65	37.06	7.31	38.50	8.19	8.29
113	1533	34.25	5.79	35.66	6.43	37.04	7.06	38.51	7.90	8.09
114	1570	34.17	5.59	35.61	6.21	37.00	6.83	38.51	7.62	7.90
115	1609	34.07	5.38	35.54	6.00	36.96	6.61	38.48	7.35	7.71
116	1648	33.95	5.19	35.46	5.80	36.90	6.39	38.45	7.10	7.52
117	1688	33.81	5.00	35.37	5.60	36.83	6.18	38.40	6.85	7.34
118	1730	33.66	4.82	35.26	5.41	36.76	5.98	38.35	6.60	7.17
119	1772	33.48	4.65	35.14	5.22	36.67	5.78	38.28	6.37	7.00
120	1815	33.29	4.49	35.01	5.04	36.57	5.58	38.20	6.15	6.83
121	1860	33.06	4.33	34.85	4.87	36.45	5.39	38.10	5.93	6.67
122	1905	32.81	4.18	34.68	4.70	36.31	5.21	37.99	5.72	6.51
123	1952	32.47	4.03	34.46	4.54	36.16	5.03	37.87	5.51	6.35
124	2000	32.13	3.89	34.24	4.38	36.01	4.86	37.75	5.32	6.20
	$\frac{E\mu(E)}{f_2}$	452.7		438.4		425.2		416.1		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	92.91		95.94		98.91		101.1		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Rh (45) f_1	Rh (45) f_2	Pd (46) f_1	Pd (46) f_2	Ag (47) f_1	Ag (47) f_2	Cd (48) f_1	Cd (48) f_2	λ(A)
0	100	18.54	1.32	20.71	5.09	26.80	9.45	21.11	11.60	124.0
1	102	18.20	1.16	20.49	4.76	26.55	8.43	21.42	11.02	121.5
2	104	17.84	1.02	20.23	4.47	26.27	7.53	21.66	10.47	119.2
3	107	17.32	1.01	19.82	4.06	25.80	6.25	21.94	9.64	115.9
4	110	16.93	1.06	19.37	3.71	25.25	5.16	22.15	8.88	112.7
5	112	16.71	1.09	19.04	3.49	24.81	4.33	22.26	8.41	110.7
6	115	16.41	1.17	18.52	3.25	24.01	3.35	22.34	7.60	107.8
7	118	16.16	1.26	18.05	3.14	23.09	2.61	22.31	6.89	105.1
8	121	15.94	1.35	17.68	3.03	22.13	2.13	22.23	6.20	102.5
9	124	15.75	1.44	17.36	2.93	21.34	1.90	22.06	5.58	100.0
10	127	15.57	1.54	17.04	2.83	20.60	1.71	21.89	5.04	97.6
11	130	15.42	1.64	16.73	2.74	19.90	1.53	21.70	4.49	95.4
12	133	15.28	1.74	16.37	2.66	19.25	1.59	21.43	3.90	93.2
13	136	15.18	1.85	16.04	2.74	18.74	1.64	21.01	3.40	91.2
14	140	15.06	2.01	15.69	2.86	18.12	1.72	20.40	2.85	88.6
15	143	15.02	2.12	15.48	2.95	17.68	1.87	19.91	2.70	86.7
16	147	14.99	2.22	15.24	3.06	17.25	2.09	19.32	2.51	84.3
17	150	14.95	2.25	15.07	3.15	16.98	2.27	18.88	2.46	82.7
18	154	14.89	2.30	14.88	3.30	16.71	2.46	18.41	2.54	80.5
19	158	14.81	2.35	14.73	3.45	16.48	2.67	18.08	2.63	78.5
20	162	14.73	2.40	14.63	3.61	16.34	2.81	17.79	2.72	76.5
21	166	14.65	2.44	14.57	3.77	16.17	2.89	17.55	2.82	74.7
22	170	14.56	2.49	14.57	3.93	15.98	2.97	17.34	2.91	72.9
23	174	14.47	2.54	14.67	3.97	15.80	3.13	17.16	3.00	71.3
24	178	14.35	2.58	14.67	3.90	15.69	3.29	17.00	3.09	69.7
25	182	14.20	2.63	14.63	3.82	15.60	3.41	16.86	3.19	68.1
26	187	14.05	2.85	14.49	3.74	15.49	3.50	16.71	3.31	66.3
27	191	13.99	3.04	14.33	3.67	15.38	3.57	16.62	3.40	64.9
28	196	14.05	3.24	14.09	3.70	15.25	3.66	16.53	3.49	63.3
29	201	14.10	3.27	13.87	3.79	15.11	3.75	16.44	3.57	61.7
30	206	14.10	3.30	13.70	3.89	14.97	3.85	16.36	3.64	60.2
31	211	14.08	3.33	13.55	3.98	14.82	3.95	16.27	3.72	58.8
32	216	14.05	3.34	13.40	4.08	14.67	4.05	16.21	3.77	57.4
33	221	13.99	3.32	13.25	4.17	14.49	4.18	16.13	3.82	56.1
34	227	13.90	3.30	13.08	4.28	14.32	4.42	16.03	3.87	54.6
35	232	13.80	3.29	12.93	4.38	14.22	4.63	15.94	3.91	53.4
36	238	13.65	3.27	12.75	4.49	14.14	4.89	15.83	3.96	52.1
37	244	13.47	3.25	12.56	4.60	14.13	5.07	15.73	4.02	50.8
38	250	13.28	3.23	12.36	4.72	14.09	5.20	15.62	4.07	49.6
39	256	13.06	3.21	12.15	4.83	14.03	5.34	15.50	4.12	48.4
40	262	12.81	3.19	11.93	4.94	13.97	5.47	15.39	4.17	47.3
41	269	12.48	3.17	11.62	5.08	13.88	5.63	15.26	4.22	46.1
42	275	12.16	3.16	11.30	5.19	13.82	5.77	15.15	4.27	45.1
43	282	11.73	3.14	10.87	5.45	13.74	5.92	15.01	4.29	44.0
44	289	11.20	3.12	10.48	5.76	13.66	6.07	14.84	4.30	42.9
45	296	10.50	3.10	10.06	6.08	13.58	6.21	14.65	4.30	41.9
46	303	9.66 M	3.16	9.61	6.45	13.50	6.35	14.43	4.30	40.9
47	311	8.62	3.76	9.09	7.09	13.41	6.43	14.16	4.31	39.9
48	318	7.86	4.36	8.74	7.69	13.27	6.49	13.88	4.31	39.0
49	326	7.03	5.14	8.38	8.42	13.07	6.57	13.54	4.32	38.0
50	334	6.23	6.04	8.07 M	9.21	12.83	6.64	13.15	4.32	37.1
51	342	5.50	7.06	7.80	10.04	12.56	6.72	12.72	4.33	36.3
52	351	4.73	8.39	7.59	11.04	12.17	6.80	12.17	4.33	35.3
53	359	4.11	9.75	7.46	11.99	11.75	6.87	11.60	4.34	34.5
54	368	3.59	11.49	7.39	13.12	11.19	6.95	10.86	4.34	33.7
55	377	3.34	13.49	7.48	14.34	10.46	7.03	10.03	4.35	32.9
56	386	3.37	15.78	7.88	15.63	9.23	7.10	8.98	4.35	32.1
57	396	4.28	18.71	8.55	16.88	7.49 M	7.76	7.60	4.35	31.3
58	406	6.33	20.50	9.21	17.75	6.01	9.46	5.65	4.33	30.5
59	415	7.82	21.25	9.72	18.56	5.10	11.27	3.36	4.32	29.9
60	426	9.29	22.19	10.42	19.57	4.37	13.89	-1.95	4.30	29.1
61	436	10.58	23.05	11.16	20.52	4.27	16.71	-15.15 M	4.29	28.4
62	447	12.27	23.98	12.22	21.58	5.40	20.38	-12.41	32.43	27.7
63	458	13.72	23.96	13.51	22.18	7.97	22.50	2.50	31.77	27.1
64	469	14.88	24.18	14.61	22.37	10.17	22.90	7.09	31.14	26.4

N	E(eV)	Rh (45) Rhodium f_1	Rh (45) Rhodium f_2	Pd (46) Palladium f_1	Pd (46) Palladium f_2	Ag (47) Silver f_1	Ag (47) Silver f_2	Cd (48) Cadmium f_1	Cd (48) Cadmium f_2	λ(A)
65	480	15.92	24.40	15.49	22.56	11.68	23.30	10.64	30.54	25.83
66	492	17.03	24.63	16.30	22.77	12.93	23.73	13.50	29.91	25.20
67	504	18.11	24.86	17.03	22.97	14.07	24.16	15.54	29.30	24.60
68	516	19.21	25.09	17.62	23.16	15.16	24.59	17.26	28.73	24.03
69	529	20.48	25.20	18.09	23.54	16.31	25.02	18.77	28.14	23.44
70	542	21.63	25.05	18.78	24.28	17.38	25.36	20.00	27.59	22.87
71	555	22.63	24.89	19.62	25.03	18.43	25.69	21.03	27.06	22.34
72	569	23.53	24.71	21.01	25.84	19.59	26.04	21.76	26.47	21.79
73	583	24.39	24.64	22.62	25.92	20.76	26.22	22.21	26.38	21.27
74	597	25.25	24.61	23.87	25.71	21.82	26.32	22.90	26.49	20.77
75	612	26.21	24.58	24.99	25.48	22.89	26.42	23.69	26.59	20.26
76	627	27.30	24.55	25.99	25.27	23.91	26.52	24.52	26.70	19.77
77	642	28.43	24.34	26.90	25.06	24.90	26.62	25.39	26.79	19.31
78	658	29.54	23.73	27.81	24.85	25.98	26.73	26.30	26.83	18.84
79	674	30.32	23.14	28.69	24.64	27.08	26.83	27.21	26.88	18.39
80	690	31.02	22.70	29.56	24.44	28.30	26.93	28.15	26.90	17.97
81	707	31.74	22.25	30.54	24.20	29.87	26.93	29.19	26.90	17.54
82	725	32.45	21.69	31.49	23.70	31.33	26.13	30.27	26.75	17.10
83	742	33.02	21.19	32.27	23.25	32.38	25.41	31.24	26.62	16.71
84	760	33.58	20.68	33.00	22.79	33.21	24.69	32.34	26.48	16.31
85	779	34.13	20.16	33.75	22.31	34.00	23.99	33.56	26.25	15.92
86	798	34.62	19.63	34.43	21.73	34.64	23.39	34.71	25.55	15.54
87	818	35.08	19.11	35.04	21.15	35.28	22.79	35.58	24.85	15.16
88	838	35.50	18.61	35.56	20.60	35.87	22.22	36.34	24.18	14.79
89	858	35.88	18.13	36.04	20.07	36.41	21.67	37.00	23.56	14.45
90	879	36.24	17.64	36.50	19.54	36.94	21.11	37.62	22.98	14.10
91	901	36.58	17.15	36.91	19.01	37.43	20.55	38.21	22.39	13.76
92	923	36.90	16.69	37.30	18.51	37.89	20.01	38.77	21.83	13.43
93	945	37.19	16.23	37.65	18.02	38.31	19.48	39.28	21.27	13.12
94	968	37.46	15.77	37.99	17.54	38.70	18.93	39.75	20.70	12.81
95	992	37.71	15.31	38.33	17.05	39.07	18.39	40.22	20.13	12.50
96	1016	37.94	14.87	38.64	16.58	39.41	17.88	40.67	19.58	12.20
97	1041	38.16	14.42	38.95	16.07	39.75	17.34	41.09	18.97	11.91
98	1067	38.35	13.97	39.19	15.56	40.02	16.80	41.42	18.35	11.62
99	1093	38.52	13.54	39.40	15.08	40.26	16.29	41.73	17.77	11.34
100	1119	38.65	13.13	39.58	14.62	40.49	15.81	41.98	17.23	11.08
101	1147	38.78	12.72	39.76	14.15	40.70	15.32	42.23	16.67	10.81
102	1175	38.90	12.33	39.95	13.71	40.90	14.85	42.46	16.14	10.55
103	1204	39.00	11.94	40.04	13.28	41.04	14.40	42.65	15.63	10.30
104	1233	39.08	11.58	40.16	12.87	41.19	13.97	42.81	15.14	10.06
105	1263	39.16	11.23	40.27	12.47	41.33	13.54	42.96	14.66	9.82
106	1294	39.23	10.88	40.35	12.08	41.45	13.13	43.09	14.20	9.58
107	1326	39.29	10.55	40.43	11.70	41.56	12.73	43.21	13.75	9.35
108	1358	39.34	10.23	40.50	11.34	41.66	12.35	43.32	13.32	9.13
109	1392	39.39	9.91	40.56	10.98	41.76	11.97	43.42	12.89	8.91
110	1426	39.42	9.60	40.61	10.64	41.85	11.61	43.49	12.48	8.69
111	1460	39.45	9.32	40.65	10.32	41.93	11.26	43.55	12.10	8.49
112	1496	39.48	9.02	40.68	9.99	42.02	10.91	43.59	11.72	8.29
113	1533	39.50	8.73	40.71	9.68	42.08	10.53	43.63	11.38	8.09
114	1570	39.50	8.44	40.72	9.38	42.12	10.18	43.67	11.06	7.90
115	1609	39.49	8.16	40.74	9.08	42.16	9.83	43.72	10.74	7.71
116	1648	39.48	7.90	40.73	8.80	42.18	9.50	43.76	10.43	7.52
117	1688	39.46	7.64	40.73	8.52	42.18	9.18	43.80	10.13	7.34
118	1730	39.42	7.39	40.72	8.25	42.19	8.86	43.85	9.83	7.17
119	1772	39.38	7.14	40.71	7.98	42.17	8.55	43.89	9.53	7.00
120	1815	39.34	6.89	40.69	7.72	42.15	8.26	43.91	9.22	6.83
121	1860	39.27	6.65	40.65	7.46	42.12	7.96	43.93	8.92	6.67
122	1905	39.19	6.43	40.60	7.21	42.08	7.69	43.93	8.64	6.51
123	1952	39.10	6.21	40.54	6.97	42.02	7.41	43.93	8.36	6.35
124	2000	39.01	5.99	40.48	6.74	41.96	7.15	43.93	8.09	6.20
	$\frac{E\mu(E)}{f_2}$	408.7		395.3		389.9		374.2		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	102.9		106.4		107.9		112.4		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	In (49) f_1	In (49) f_2	Sn (50) f_1	Sn (50) f_2	Sb (51) f_1	Sb (51) f_2	Te (52) f_1	Te (52) f_2	λ(A)
0	100	20.59	27.45	25.60	27.04	25.26	21.77	21.60	28.63	124.0
1	102	22.04	26.69	26.05	25.97	26.45	20.99	24.03	26.96	121.5
2	104	23.34	25.82	26.52	24.96	27.75	20.25	25.65	25.41	119.2
3	107	25.20	24.59	27.22	23.54	29.84	17.56	27.76	23.30	115.9
4	110	26.99	22.60	27.99	22.25	30.42	14.87	29.78	21.42	112.7
5	112	27.87	21.29	28.49	21.26	30.47	13.34	30.98	18.89	110.7
6	115	28.97	19.05	28.88	19.26	30.44	11.38	31.60	15.71	107.8
7	118	29.58	16.65	28.51	17.84	30.42	9.57	31.52	13.13	105.1
8	121	29.64	14.51	28.41	17.18	29.83	7.44	31.20	10.82	102.5
9	124	29.48	12.59	28.51	16.56	28.99	5.82	30.57	8.61	100.0
10	127	29.13	10.93	28.77	15.98	27.95	4.59	29.55	6.90	97.6
11	130	28.68	9.50	29.24	15.44	26.89	3.67	28.50	5.55	95.4
12	133	28.22	8.20	29.89	14.92	25.83	2.94	27.41	4.49	93.2
13	136	27.67	6.98	31.31	14.43	24.71	2.52	26.34	3.65	91.2
14	140	26.79	5.43	32.71	10.91	23.58	2.36	24.87	2.79	88.6
15	143	26.00	4.39	32.27	8.38	22.90	2.25	23.91	2.60	86.7
16	147	24.78	3.32	30.96	5.95	22.05	2.12	22.79	2.37	84.3
17	150	23.77	2.71	29.64	4.63	21.42	2.09	22.00	2.22	82.7
18	154	22.61	2.38	27.98	3.75	20.71	2.24	21.04	2.31	80.5
19	158	21.60	2.11	26.45	3.05	20.14	2.45	20.31	2.53	78.5
20	162	20.64	1.87	25.07	3.09	19.68	2.67	19.74	2.76	76.5
21	166	19.80	1.93	24.14	3.12	19.32	2.91	19.28	3.00	74.7
22	170	19.04	2.00	23.38	3.16	19.07	3.17	18.96	3.26	72.9
23	174	18.40	2.08	22.72	3.24	18.90	3.35	18.72	3.45	71.3
24	178	17.84	2.27	22.17	3.35	18.74	3.47	18.51	3.58	69.7
25	182	17.34	2.49	21.71	3.46	18.59	3.59	18.31	3.71	68.1
26	187	16.89	2.77	21.24	3.61	18.43	3.75	18.10	3.89	66.3
27	191	16.58	2.97	20.92	3.73	18.32	3.89	17.96	4.03	64.9
28	196	16.26	3.22	20.60	3.85	18.22	4.01	17.83	4.17	63.3
29	201	16.03	3.45	20.32	3.94	18.13	4.12	17.70	4.29	61.7
30	206	15.82	3.64	20.06	4.04	18.04	4.23	17.60	4.41	60.2
31	211	15.65	3.82	19.85	4.14	17.97	4.34	17.51	4.53	58.8
32	216	15.51	3.97	19.66	4.21	17.91	4.42	17.43	4.62	57.4
33	221	15.40	4.12	19.48	4.27	17.85	4.49	17.36	4.70	56.1
34	227	15.29	4.22	19.28	4.35	17.77	4.58	17.27	4.80	54.6
35	232	15.17	4.28	19.13	4.41	17.71	4.65	17.20	4.88	53.4
36	238	15.04	4.36	18.95	4.48	17.64	4.74	17.12	4.98	52.1
37	244	14.90	4.44	18.79	4.56	17.58	4.83	17.05	5.08	50.8
38	250	14.77	4.49	18.65	4.63	17.51	4.91	16.98	5.17	49.6
39	256	14.63	4.52	18.51	4.70	17.46	5.00	16.92	5.27	48.4
40	262	14.48	4.56	18.39	4.77	17.41	5.08	16.87	5.36	47.3
41	269	14.29	4.59	18.26	4.85	17.36	5.18	16.82	5.48	46.1
42	275	14.13	4.63	18.17	4.93	17.34	5.26	16.80	5.57	45.1
43	282	13.93	4.65	18.07	4.96	17.31	5.31	16.78	5.63	44.0
44	289	13.70	4.66	17.96	4.99	17.27	5.34	16.75	5.66	42.9
45	296	13.45	4.67	17.83	5.01	17.20	5.37	16.69	5.70	41.9
46	303	13.19	4.68	17.69	5.03	17.12	5.39	16.62	5.73	40.9
47	311	12.85	4.69	17.53	5.05	17.02	5.42	16.53	5.77	39.9
48	318	12.52	4.70	17.37	5.07	16.92	5.45	16.43	5.80	39.0
49	326	12.12	4.71	17.18	5.10	16.79	5.48	16.32	5.84	38.0
50	334	11.67	4.72	16.98	5.12	16.64	5.50	16.19	5.88	37.1
51	342	11.17	4.73	16.77	5.14	16.49	5.53	16.05	5.91	36.3
52	351	10.56	4.74	16.51	5.16	16.29	5.56	15.88	5.95	35.3
53	359	9.92	4.75	16.27	5.19	16.09	5.59	15.72	5.99	34.5
54	368	9.10	4.76	15.97	5.21	15.86	5.62	15.52	6.03	33.7
55	377	8.17	4.77	15.65	5.23	15.60	5.65	15.30	6.06	32.9
56	386	7.03	4.78	15.30	5.25	15.31	5.68	15.07	6.10	32.1
57	396	5.54	4.79	14.89	5.27	14.98	5.69	14.81	6.13	31.3
58	406	3.42	4.78	14.40	5.22	14.58	5.65	14.49	6.10	30.5
59	415	0.90	4.77	13.85	5.18	14.13	5.62	14.14	6.07	29.9
60	426	-4.66	4.77	13.08	5.13	13.50	5.58	13.64	6.03	29.1
61	436	-15.80	4.76	12.27	5.09	12.84	5.54	13.13	6.00	28.4
62	447	-21.64	M 38.24	11.13	5.05	11.92	5.50	12.48	5.97	27.7
63	458	-2.02	37.20	9.72	5.01	10.83	5.46	11.71	5.93	27.1
64	469	4.39	36.21	7.98	4.97	9.50	5.41	10.78	5.89	26.4

N	E(eV)	In (49) Indium f_1	In (49) Indium f_2	Sn (50) Tin f_1	Sn (50) Tin f_2	Sb (51) Antimony f_1	Sb (51) Antimony f_2	Te (52) Tellurium f_1	Te (52) Tellurium f_2	λ(A)
65	480	9.11	35.26	5.46	4.93	7.80	5.36	9.72	5.84	25.83
66	492	12.59	34.28	0.58	4.88	5.11	5.32	8.32	5.80	25.20
67	504	15.13	33.36	-10.78	4.84	1.38	5.27	6.51	5.75	24.60
68	516	17.30	32.47	-16.76 M	34.78	-5.29	5.22	4.27	5.71	24.03
69	529	19.18	31.56	3.44	33.93	-34.12 M	40.41	0.91	5.66	23.44
70	542	20.62	30.70	8.85	33.13	-6.88	39.05	-3.86	5.60	22.87
71	555	21.90	29.88	13.19	32.36	7.61	37.77	-12.51	5.54	22.34
72	569	22.96	29.04	16.20	31.51	12.91	36.46	-53.41 M	5.48	21.79
73	583	23.78	28.30	18.40	30.74	16.44	35.30	-23.05	63.61	21.27
74	597	24.41	27.61	20.23	30.02	19.20	34.22	8.28	57.49	20.77
75	612	24.87	26.91	21.92	29.29	21.67	33.13	19.12	51.72	20.26
76	627	24.87	26.24	23.25	28.59	23.59	32.10	24.74	46.64	19.77
77	642	24.47	26.25	24.41	27.90	25.22	31.08	28.72	42.17	19.31
78	658	24.68	27.67	25.37	27.13	26.57	29.97	31.04	37.97	18.84
79	674	26.01	29.13	26.03	26.40	27.59	28.93	32.07	34.27	18.39
80	690	27.85	29.19	26.28	25.84	28.36	28.15	32.14	31.74	17.97
81	707	29.55	28.58	26.35	25.43	29.08	27.40	31.86	29.63	17.54
82	725	30.72	27.97	26.50	26.06	29.72	26.67	31.54	28.85	17.10
83	742	31.57	27.42	27.17	26.65	30.11	26.01	31.59	28.14	16.71
84	760	32.33	26.87	28.18	27.27	30.24	25.35	31.43	27.43	16.31
85	779	32.97	26.36	29.67	27.76	30.01	24.89	31.07	26.92	15.92
86	798	33.59	26.19	31.05	27.29	30.00	25.66	30.85	27.60	15.54
87	818	34.35	26.02	32.23	26.82	30.51	26.47	31.37	28.32	15.16
88	838	35.22	25.86	33.17	26.36	31.53	27.29	32.49	29.04	14.79
89	858	36.28	25.54	33.91	25.99	33.26	27.64	33.88	29.33	14.45
90	879	37.16	24.86	34.70	25.76	34.62	27.01	35.38	28.74	14.10
91	901	37.95	24.19	35.58	25.53	35.73	26.37	36.35	28.15	13.76
92	923	38.60	23.55	36.59	25.31	36.50	25.76	37.14	27.58	13.43
93	945	39.17	22.94	37.56	24.79	37.15	25.42	37.80	27.25	13.12
94	968	39.72	22.34	38.46	24.14	37.88	25.17	38.55	27.01	12.81
95	992	40.25	21.75	39.23	23.50	38.72	24.93	39.50	26.77	12.50
96	1016	40.75	21.17	39.93	22.87	39.77	24.60	40.54	26.43	12.20
97	1041	41.23	20.51	40.58	22.18	40.71	23.86	41.57	25.66	11.91
98	1067	41.62	19.85	41.11	21.48	41.43	23.12	42.34	24.87	11.62
99	1093	41.95	19.24	41.56	20.82	42.02	22.42	42.97	24.13	11.34
100	1119	42.25	18.66	41.96	20.19	42.54	21.75	43.52	23.42	11.08
101	1147	42.54	18.06	42.36	19.55	43.03	21.07	44.05	22.71	10.81
102	1175	42.79	17.50	42.69	18.95	43.45	20.43	44.50	22.03	10.55
103	1204	43.02	16.95	43.00	18.36	43.83	19.81	44.92	21.36	10.30
104	1233	43.22	16.44	43.27	17.80	44.17	19.21	45.29	20.73	10.06
105	1263	43.40	15.93	43.52	17.26	44.48	18.63	45.63	20.11	9.82
106	1294	43.55	15.43	43.75	16.72	44.76	18.06	45.93	19.51	9.58
107	1326	43.70	14.94	43.96	16.20	45.02	17.51	46.22	18.92	9.35
108	1358	43.83	14.49	44.14	15.71	45.26	16.98	46.48	18.36	9.13
109	1392	43.95	14.03	44.31	15.21	45.48	16.46	46.73	17.80	8.91
110	1426	44.05	13.59	44.47	14.75	45.68	15.96	46.95	17.27	8.69
111	1460	44.15	13.18	44.60	14.30	45.87	15.49	47.16	16.77	8.49
112	1496	44.24	12.76	44.70	13.86	46.04	15.01	47.38	16.25	8.29
113	1533	44.29	12.36	44.82	13.44	46.20	14.53	47.57	15.73	8.09
114	1570	44.35	11.98	44.92	13.03	46.34	14.07	47.72	15.23	7.90
115	1609	44.40	11.60	45.01	12.63	46.45	13.62	47.86	14.74	7.71
116	1648	44.44	11.25	45.09	12.25	46.55	13.19	47.98	14.27	7.52
117	1688	44.48	10.90	45.16	11.88	46.64	12.77	48.10	13.82	7.34
118	1730	44.52	10.55	45.23	11.52	46.73	12.36	48.21	13.37	7.17
119	1772	44.54	10.22	45.29	11.16	46.80	11.96	48.29	12.93	7.00
120	1815	44.56	9.89	45.34	10.81	46.86	11.57	48.37	12.49	6.83
121	1860	44.56	9.56	45.37	10.46	46.91	11.19	48.43	12.06	6.67
122	1905	44.55	9.25	45.39	10.13	46.94	10.83	48.47	11.66	6.51
123	1952	44.53	8.95	45.41	9.80	46.96	10.47	48.50	11.26	6.35
124	2000	44.52	8.66	45.42	9.49	46.98	10.12	48.53	10.87	6.20
	$\frac{E_M(E)}{f_2}$	366.3		354.3		345.4		329.6		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	114.8		118.7		121.8		127.6		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	I (53)		Xe (54)		Cs (55)		Ba (56)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	22.24	28.60	9.48	38.52	-4.04	35.67	-15.78	30.38	124.0
1	102	24.05	27.07	12.95	38.73	-1.19	37.81	-10.78	36.77	121.5
2	104	25.50	25.66	16.28	38.60	1.94	39.94	-5.03	43.74	119.2
3	107	27.31	23.72	21.15	37.50	7.01	41.74	4.97	46.09	115.9
4	110	28.84	21.97	25.54	35.41	12.31	42.60	13.29	47.13	112.7
5	112	30.01	20.90	27.99	33.88	15.78	42.81	18.62	46.95	110.7
6	115	31.78	19.43	31.26	30.73	20.80	41.93	26.54	45.67	107.8
7	118	33.30	15.73	33.76	27.67	25.55	40.55	33.94	41.81	105.1
8	121	33.19	12.80	35.38	23.62	29.64	38.11	38.16	35.96	102.5
9	124	32.73	10.46	36.00	20.20	33.10	35.29	41.55	31.08	100.0
10	127	32.09	8.60	36.05	16.95	36.02	32.00	43.73	26.95	97.6
11	130	31.35	6.83	35.60	14.25	38.28	28.36	44.30	20.19	95.4
12	133	30.37	5.35	34.86	12.03	39.50	24.50	43.26	15.04	93.2
13	136	29.26	4.21	34.03	10.16	39.86	21.08	41.09	12.54	91.2
14	140	27.77	3.08	32.82	8.11	39.62	16.99	39.15	9.98	88.6
15	143	26.58	2.46	31.87	6.88	38.91	14.52	37.89	8.42	86.7
16	147	25.26	2.37	30.61	5.56	37.84	11.80	36.23	6.74	84.3
17	150	24.47	2.31	29.69	4.78	36.95	10.09	34.97	5.80	82.7
18	154	23.57	2.24	28.53	3.97	35.68	8.20	33.63	5.08	80.5
19	158	22.81	2.33	27.45	3.36	34.40	6.73	32.50	4.47	78.5
20	162	22.17	2.49	26.45	2.92	33.15	5.55	31.50	4.03	76.5
21	166	21.64	2.65	25.52	2.63	31.92	4.65	30.65	3.68	74.7
22	170	21.23	2.81	24.68	2.44	30.80	3.96	29.87	3.36	72.9
23	174	20.87	2.96	23.92	2.34	29.74	3.43	29.20	3.23	71.3
24	178	20.52	3.08	23.23	2.30	28.76	3.06	28.61	3.11	69.7
25	182	20.15	3.21	22.62	2.32	27.85	2.79	28.12	2.99	68.1
26	187	19.78	3.60	21.95	2.42	26.85	2.61	27.58	2.86	66.3
27	191	19.59	4.01	21.46	2.53	26.09	2.55	27.15	2.76	64.9
28	196	19.64	4.27	20.93	2.70	25.28	2.55	26.65	2.68	63.3
29	201	19.61	4.40	20.50	2.90	24.57	2.62	26.22	2.66	61.7
30	206	19.56	4.54	20.12	3.11	23.94	2.74	25.84	2.65	60.2
31	211	19.51	4.67	19.78	3.33	23.38	2.89	25.49	2.63	58.8
32	216	19.48	4.78	19.51	3.56	22.90	3.09	25.15	2.62	57.4
33	221	19.44	4.87	19.30	3.79	22.50	3.30	24.82	2.63	56.1
34	227	19.40	4.99	19.08	4.06	22.07	3.57	24.46	2.64	54.6
35	232	19.36	5.08	18.92	4.28	21.79	3.80	24.15	2.66	53.4
36	238	19.33	5.20	18.79	4.54	21.50	4.08	23.79	2.73	52.1
37	244	19.30	5.31	18.69	4.77	21.26	4.35	23.43	2.82	50.8
38	250	19.27	5.42	18.61	5.00	21.07	4.62	23.08	2.96	49.6
39	256	19.26	5.54	18.56	5.21	20.93	4.88	22.77	3.15	48.4
40	262	19.26	5.65	18.53	5.41	20.82	5.13	22.50	3.37	47.3
41	269	19.27	5.78	18.52	5.63	20.73	5.41	22.23	3.67	46.1
42	275	19.31	5.89	18.52	5.78	20.68	5.62	22.05	3.92	45.1
43	282	19.36	5.96	18.53	5.97	20.66	5.87	21.90	4.23	44.0
44	289	19.40	6.01	18.56	6.12	20.66	6.09	21.77	4.53	42.9
45	296	19.41	6.06	18.60	6.26	20.68	6.29	21.70	4.83	41.9
46	303	19.41	6.10	18.63	6.38	20.70	6.48	21.66	5.12	40.9
47	311	19.42	6.16	18.67	6.51	20.75	6.66	21.65	5.42	39.9
48	318	19.41	6.20	18.72	6.60	20.81	6.82	21.66	5.68	39.0
49	326	19.39	6.25	18.76	6.70	20.87	6.96	21.71	5.95	38.0
50	334	19.37	6.30	18.79	6.78	20.94	7.10	21.78	6.19	37.1
51	342	19.35	6.35	18.82	6.84	21.01	7.21	21.85	6.42	36.3
52	351	19.32	6.41	18.85	6.90	21.09	7.33	21.96	6.63	35.3
53	359	19.28	6.45	18.86	6.94	21.15	7.41	22.06	6.81	34.5
54	368	19.24	6.51	18.86	6.98	21.23	7.48	22.18	6.98	33.7
55	377	19.20	6.56	18.85	7.00	21.30	7.55	22.30	7.13	32.9
56	386	19.16	6.61	18.82	7.02	21.35	7.60	22.42	7.26	32.1
57	396	19.13	6.65	18.77	7.03	21.41	7.65	22.55	7.38	31.3
58	406	19.07	6.62	18.68	7.04	21.46	7.67	22.67	7.48	30.5
59	415	18.97	6.59	18.59	7.05	21.48	7.69	22.77	7.54	29.9
60	426	18.82	6.55	18.46	7.09	21.51	7.71	22.88	7.62	29.1
61	436	18.65	6.52	18.34	7.12	21.52	7.71	22.97	7.65	28.4
62	447	18.43	6.49	18.20	7.16	21.55	7.72	23.05	7.69	27.7
63	458	18.18	6.45	18.08	7.15	21.51	7.61	23.11	7.70	27.1
64	469	17.86	6.40	17.87	7.10	21.42	7.57	23.15	7.71	26.4

N	E(eV)	I (53) Iodine f_1	I (53) Iodine f_2	Xe (54) Xenon f_1	Xe (54) Xenon f_2	Cs (55) Cesium f_1	Cs (55) Cesium f_2	Ba (56) Barium f_1	Ba (56) Barium f_2	λ(A)
65	480	17.52	6.36	17.63	7.06	21.32	7.53	23.17	7.71	25.83
66	492	17.05	6.31	17.31	7.01	21.17	7.48	23.14	7.69	25.20
67	504	16.51	6.26	16.91	6.96	21.00	7.44	23.09	7.69	24.60
68	516	15.92	6.22	16.46	6.92	20.80	7.40	23.04	7.76	24.03
69	529	15.16	6.16	15.91	6.86	20.56	7.35	23.06	7.79	23.44
70	542	14.17	6.10	15.23	6.79	20.24	7.28	23.01	7.72	22.87
71	555	13.06	6.04	14.45	6.72	19.90	7.21	22.91	7.66	22.34
72	569	11.49	5.97	13.41	6.64	19.45	7.13	22.74	7.59	21.79
73	583	9.30	5.90	12.14	6.56	18.89	7.04	22.51	7.51	21.27
74	597	5.93	5.84	10.45	6.48	18.23	6.96	22.24	7.42	20.77
75	612	-1.89	5.77	8.11	6.40	17.42	6.88	21.90	7.34	20.26
76	627	-19.64 M	5.71	5.15	6.32	16.40	6.80	21.44	7.26	19.77
77	642	-2.62	38.64	0.21	6.24	15.16	6.71	20.93	7.17	19.31
78	658	7.21	36.99	-18.46	6.16	13.38	6.60	20.25	7.08	18.84
79	674	13.82	35.46	-40.41 M	58.39	11.11	6.50	19.42	6.99	18.39
80	690	17.07	34.26	0.56	53.95	7.24	6.42	18.34	6.90	17.97
81	707	19.16	33.11	15.56	49.52	-0.42	6.35	16.97	6.80	17.54
82	725	21.08	31.97	22.88	44.16	-35.83 M	6.25	14.96	6.70	17.10
83	742	23.04	30.96	26.62	39.73	3.82	41.58	11.75	6.60	16.71
84	760	25.53	29.95	28.68	35.61	12.65	39.52	3.99	6.49	16.31
85	779	28.31	28.96	30.01	32.22	19.41	37.50	-19.81 M	6.39	15.92
86	798	30.77	28.16	30.42	31.23	23.25	35.59	7.62	34.43	15.54
87	818	31.77	27.37	30.88	30.25	25.94	33.74	14.76	33.59	15.16
88	838	31.78	26.61	31.47	29.31	27.81	32.02	19.63	32.80	14.79
89	858	31.07	26.44	32.03	28.46	29.11	30.64	22.92	32.04	14.45
90	879	30.77	27.48	32.27	27.66	30.10	29.71	25.37	31.28	14.10
91	901	31.46	28.58	32.48	26.87	30.98	28.80	27.47	30.53	13.76
92	923	32.84	29.69	31.73	26.12	31.70	27.93	29.29	29.81	13.43
93	945	34.97	29.45	31.94	28.22	32.14	27.15	30.75	29.03	13.12
94	968	36.49	28.60	32.93	28.63	32.19	26.39	31.94	28.22	12.81
95	992	37.69	27.76	34.33	29.06	31.45	25.64	33.00	27.41	12.50
96	1016	38.58	26.98	35.89	29.28	29.39	26.03	33.78	26.65	12.20
97	1041	39.33	26.30	37.44	28.52	31.08	32.40	34.11	25.88	11.91
98	1067	40.04	25.68	38.47	27.90	34.85	31.47	34.46	25.90	11.62
99	1093	40.73	25.10	39.41	27.31	37.31	30.59	35.01	25.93	11.34
100	1119	41.34	24.54	40.24	26.75	38.79	29.76	35.67	25.95	11.08
101	1147	41.97	23.97	41.03	26.17	40.14	28.91	36.42	25.97	10.81
102	1175	42.56	23.42	41.79	25.62	41.29	28.10	37.21	25.99	10.55
103	1204	43.12	22.88	42.50	25.07	42.24	27.30	38.10	26.02	10.30
104	1233	43.68	22.37	43.22	24.54	43.10	26.55	39.09	26.04	10.06
105	1263	44.26	21.81	43.94	23.96	43.90	25.79	40.23	25.90	9.82
106	1294	44.76	21.16	44.62	23.24	44.60	25.02	41.25	25.39	9.58
107	1326	45.21	20.52	45.15	22.53	45.24	24.26	42.15	24.89	9.35
108	1358	45.60	19.92	45.63	21.87	45.83	23.55	42.94	24.40	9.13
109	1392	45.96	19.31	46.07	21.19	46.36	22.83	43.68	23.91	8.91
110	1426	46.28	18.74	46.44	20.56	46.83	22.15	44.38	23.44	8.69
111	1460	46.57	18.19	46.79	19.95	47.27	21.50	45.06	23.00	8.49
112	1496	46.85	17.64	47.11	19.35	47.69	20.85	45.80	22.49	8.29
113	1533	47.09	17.08	47.39	18.76	48.05	20.20	46.42	21.85	8.09
114	1570	47.31	16.56	47.66	18.21	48.39	19.58	46.97	21.24	7.90
115	1609	47.51	16.04	47.91	17.66	48.69	18.97	47.46	20.63	7.71
116	1648	47.69	15.54	48.12	17.13	48.96	18.39	47.89	20.05	7.52
117	1688	47.85	15.06	48.33	16.62	49.22	17.83	48.29	19.48	7.34
118	1730	48.00	14.59	48.53	16.12	49.47	17.27	48.68	18.92	7.17
119	1772	48.14	14.13	48.70	15.62	49.69	16.72	49.02	18.37	7.00
120	1815	48.25	13.68	48.85	15.14	49.88	16.18	49.33	17.82	6.83
121	1860	48.36	13.24	49.00	14.66	50.06	15.65	49.62	17.27	6.67
122	1905	48.42	12.82	49.10	14.21	50.19	15.15	49.84	16.76	6.51
123	1952	48.49	12.41	49.20	13.76	50.31	14.66	50.07	16.25	6.35
124	2000	48.57	12.01	49.31	13.33	50.44	14.18	50.30	15.76	6.20
	$\frac{E\mu(E)}{f_2}$	331.4		320.3		316.4		306.2		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	126.9		131.3		132.9		137.3		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	La (57)		Ce (58)		Pr (59)		Nd (60)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	6.84	9.53	11.67	2.95	8.14	4.16	14.45	4.92	124.0
1	102	6.19	10.35	10.96	3.15	6.93	4.21	14.05	4.76	121.5
2	104	5.40	11.16	10.20	3.44	5.56	4.26	13.54	4.61	119.2
3	107	3.72	12.47	8.97	3.95	3.24	4.54	12.54	4.40	115.9
4	110	0.[illegible]	15.66	7.49	4.59	0.25	5.01	11.23	4.21	112.7
5	112	-0.68	19.31	6.09	5.21	-2.72	5.55	10.02	4.22	110.7
6	115	-1.00	26.97	3.47	6.51	-7.68	8.07	7.83	4.35	107.8
7	118	1.80	38.81	-0.57	9.00	-12.36	17.31	4.57	4.89	105.1
8	121	18.28	45.08	-7.87	12.89	-12.45	23.42	0.92	7.92	102.5
9	124	27.83	37.82	1.40	37.88	-13.81	30.43	-2.26	12.64	100.0
10	127	32.69	32.02	14.16	39.71	-9.26	44.66	-4.18	20.29	97.6
11	130	34.71	27.79	25.18	31.78	4.74	64.26	-0.06	32.24	95.4
12	133	36.00	24.19	28.73	26.75	24.58	54.03	7.89	37.23	93.2
13	136	36.93	21.13	30.35	22.74	29.88	45.61	16.88	36.41	91.2
[illegible]	140	37.44	17.14	31.44	18.50	34.17	36.68	23.95	32.95	88.6
15	143	37.14	14.67	31.60	16.07	35.18	32.99	26.98	30.08	86.7
16	147	36.54	11.98	31.48	13.39	36.28	28.73	29.99	26.72	84.3
17	150	36.01	10.33	31.17	11.71	36.69	26.04	31.46	24.50	82.7
18	154	35.14	8.51	30.44	10.11	37.11	23.33	32.79	21.87	80.5
19	158	34.34	7.05	29.88	8.95	37.91	20.96	33.60	19.26	78.5
20	162	33.46	5.64	29.36	7.98	38.28	17.86	34.01	17.01	76.5
21	166	32.46	4.48	28.85	7.20	38.01	14.54	34.07	15.06	74.7
22	170	31.34	3.63	28.36	6.51	36.54	12.22	33.86	13.43	72.9
23	174	30.38	3.14	27.89	5.97	35.40	11.10	33.60	12.08	71.3
24	178	29.52	2.72	27.41	5.50	34.43	10.11	33.27	10.89	69.7
25	182	28.71	2.36	26.92	5.10	33.68	9.16	32.88	9.83	68.1
26	187	27.68	1.99	26.41	4.87	32.70	8.10	32.29	8.68	66.3
27	191	26.80	1.82	26.05	4.70	31.88	7.51	31.78	7.87	64.9
28	196	25.90	2.07	25.70	4.50	30.91	6.90	30.90	7.17	63.3
29	201	25.33	2.35	25.30	4.25	29.99	6.53	30.25	6.86	61.7
30	206	24.85	2.51	24.88	4.09	29.25	6.36	29.74	6.56	60.2
31	211	24.43	2.66	24.46	4.09	28.65	6.21	29.32	6.29	58.8
32	216	24.05	2.82	24.13	4.09	28.08	6.05	28.94	6.05	57.4
33	221	23.72	2.98	23.83	4.10	27.56	5.97	28.57	5.82	56.1
34	227	23.35	3.18	23.48	4.16	27.00	5.92	28.12	5.56	54.6
35	232	23.07	3.36	23.20	4.20	26.57	5.88	27.73	5.41	53.4
36	238	22.77	3.60	22.89	4.33	26.07	5.83	27.27	5.27	52.1
37	244	22.51	3.85	22.59	4.47	25.53	5.78	26.80	5.16	50.8
38	250	22.27	4.12	22.29	4.62	24.95	5.85	26.31	5.14	49.6
39	256	22.08	4.40	22.02	4.92	24.36	5.96	25.81	5.17	48.4
40	262	21.92	4.70	21.84	5.23	23.80	6.26	25.30	5.25	47.3
41	269	21.77	5.07	21.69	5.58	23.10	6.61	24.69	5.51	46.1
42	275	21.70	5.40	21.61	5.88	22.42	7.18	24.16	5.92	45.1
43	282	21.72	5.81	21.56	6.23	22.01	8.28	23.85	6.66	44.0
44	289	21.79	6.14	21.55	6.59	22.07	9.52	23.71	7.21	42.9
45	296	21.87	6.41	21.59	6.94	22.48	10.38	23.67	7.77	41.9
46	303	22.00	6.69	21.70	7.30	22.96	10.96	23.70	8.28	40.9
47	311	22.18	6.94	21.96	7.69	23.63	11.53	23.79	8.87	39.9
48	318	22.31	7.09	22.16	7.83	24.12	11.75	23.97	9.37	39.0
49	326	22.43	7.26	22.35	7.98	24.61	11.99	24.34	9.93	38.0
50	334	22.56	7.43	22.51	8.14	25.12	12.23	24.77	10.28	37.1
51	342	22.71	7.60	22.67	8.28	25.68	12.42	25.21	10.63	36.3
52	351	22.89	7.73	22.84	8.43	26.37	12.59	25.71	10.73	35.3
53	359	23.03	7.82	22.98	8.56	26.97	12.40	26.10	10.81	34.5
54	368	23.17	7.92	23.16	8.70	27.48	12.12	26.49	10.84	33.7
55	377	23.30	8.02	23.35	8.81	27.86	11.85	26.81	10.83	32.9
56	386	23.44	8.12	23.51	8.90	28.14	11.60	27.09	10.82	32.1
57	396	23.61	8.23	23.69	9.01	28.39	11.33	27.35	10.81	31.3
58	406	23.80	8.29	23.88	9.11	28.56	11.11	27.71	10.78	30.5
59	415	23.94	8.29	24.07	9.20	28.71	10.91	27.83	10.74	29.9
60	426	24.08	8.29	24.28	9.20	28.85	10.69	28.06	10.70	29.1
61	436	24.18	8.29	24.44	9.20	28.93	10.49	28.27	10.66	28.4
62	447	24.28	8.29	24.59	9.20	28.99	10.32	28.48	10.63	27.7
63	458	24.37	8.29	24.72	9.20	29.05	10.17	28.68	10.58	27.1
64	469	24.45	8.26	24.83	9.20	29.08	10.03	28.85	10.52	26.4

N	E(eV)	La (57) Lanthanum f_1	La (57) Lanthanum f_2	Ce (58) Cerium f_1	Ce (58) Cerium f_2	Pr (59) Praseodymium f_1	Pr (59) Praseodymium f_2	Nd (60) Neodymium f_1	Nd (60) Neodymium f_2	λ(A)
65	480	24.50	8.23	24.94	9.20	29.10	9.90	29.00	10.46	25.83
66	492	24.53	8.20	25.05	9.20	29.10	9.79	29.15	10.40	25.20
67	504	24.55	8.18	25.16	9.18	29.07	9.71	29.29	10.34	24.60
68	516	24.56	8.15	25.26	9.14	29.08	9.69	29.43	10.28	24.03
69	529	24.55	8.11	25.33	9.08	29.12	9.65	29.57	10.21	23.44
70	542	24.52	8.05	25.38	9.00	29.15	9.56	29.69	10.12	22.87
71	555	24.47	8.00	25.40	8.93	29.18	9.48	29.80	10.03	22.34
72	569	24.38	7.93	25.39	8.83	29.18	9.38	29.88	9.93	21.79
73	583	24.24	7.86	25.35	8.74	29.16	9.28	29.94	9.82	21.27
74	597	24.07	7.78	25.26	8.65	29.12	9.18	29.98	9.71	20.77
75	612	23.86	7.71	25.14	8.55	29.05	9.08	30.00	9.60	20.26
76	627	23.61	7.64	25.00	8.46	28.98	8.98	30.01	9.50	19.77
77	642	23.31	7.55	24.81	8.36	28.88	8.87	30.00	9.38	19.31
78	658	22.91	7.45	24.55	8.23	28.72	8.73	29.96	9.24	18.84
79	674	22.43	7.34	24.24	8.10	28.54	8.60	29.85	9.10	18.39
80	690	21.83	7.27	23.85	8.01	28.30	8.50	29.73	9.00	17.97
81	707	21.13	7.19	23.38	7.92	28.04	8.41	29.58	8.90	17.54
82	725	20.18	7.08	22.78	7.79	27.71	8.27	29.37	8.75	17.10
83	742	19.02	6.98	22.13	7.67	27.35	8.15	29.16	8.62	16.71
84	760	17.39	6.88	21.23	7.55	26.87	8.02	28.85	8.48	16.31
85	779	15.15	6.77	20.12	7.43	26.29	7.89	28.48	8.35	15.92
86	798	11.58	6.67	18.63	7.30	25.57	7.75	28.03	8.20	15.54
87	818	-2.44	6.57	16.54	7.17	24.65	7.61	27.41	8.05	15.16
88	838	-8.15 M	35.41	13.16	7.04	23.45	7.48	26.72	7.91	14.79
89	858	11.58	34.38	5.37	6.93	21.97	7.35	25.84	7.78	14.45
90	879	18.34	33.38	-11.49 M	6.81	19.98	7.21	24.55	7.63	14.10
91	901	22.13	32.40	7.12	37.19	16.34	7.08	22.97	7.49	13.76
92	923	25.19	31.46	15.87	35.95	10.05 M	6.95	20.49	7.35	13.43
93	945	27.37	30.59	21.02	34.78	-16.36	37.24	13.48	7.22	13.12
94	968	29.03	29.73	24.66	33.63	13.53	36.08	1.98 M	7.09	12.81
95	992	30.48	28.87	27.03	32.50	20.22	34.94	11.17	30.51	12.50
96	1016	31.61	28.06	28.91	31.46	25.85	33.87	21.07	30.04	12.20
97	1041	32.23	27.26	30.15	30.50	29.18	32.81	25.12	29.57	11.91
98	1067	32.85	27.24	31.10	30.42	31.60	31.75	27.59	29.08	11.62
99	1093	33.56	27.22	32.16	30.34	33.58	30.74	29.94	28.62	11.34
100	1119	34.37	27.20	33.28	30.26	35.18	29.79	31.47	28.17	11.08
101	1147	35.26	27.17	34.46	30.18	36.59	28.83	33.06	27.71	10.81
102	1175	36.15	27.15	35.61	30.10	37.65	27.91	34.22	27.27	10.55
103	1204	37.11	27.13	36.80	30.02	38.54	27.02	35.23	26.83	10.30
104	1233	38.15	27.11	38.06	29.94	38.90	26.18	35.88	26.41	10.06
105	1263	39.28	26.96	39.37	29.73	39.17	25.64	36.50	26.19	9.82
106	1294	40.33	26.53	40.64	29.22	39.51	25.76	37.09	26.43	9.58
107	1326	41.26	26.10	41.70	28.71	39.96	25.88	37.81	26.68	9.35
108	1358	42.12	25.68	42.70	28.22	40.63	26.00	38.65	26.92	9.13
109	1392	42.95	25.26	43.69	27.73	41.42	26.12	39.63	27.18	8.91
110	1426	43.75	24.85	44.60	27.25	42.26	26.24	40.65	27.43	8.69
111	1460	44.56	24.46	45.52	26.80	43.13	26.36	41.94	27.68	8.49
112	1496	45.45	23.99	46.54	26.25	44.21	26.25	43.36	27.71	8.29
113	1533	46.20	23.30	47.39	25.46	45.79	26.68	43.88	27.09	8.09
114	1570	46.86	22.64	48.14	24.72	47.09	25.86	44.27	26.50	7.90
115	1609	47.44	21.99	48.83	23.98	48.22	25.05	46.78	26.85	7.71
116	1648	47.93	21.37	49.39	23.27	49.02	24.28	48.13	26.02	7.52
117	1688	48.40	20.76	49.92	22.59	49.80	23.54	49.25	25.21	7.34
118	1730	48.84	20.16	50.43	21.91	50.47	22.80	50.10	24.41	7.17
119	1772	49.23	19.57	50.87	21.23	51.05	22.07	50.83	23.63	7.00
120	1815	49.58	19.00	51.27	20.57	51.57	21.36	51.45	22.87	6.83
121	1860	49.91	18.43	51.65	19.91	52.00	20.65	51.99	22.12	6.67
122	1905	50.16	17.89	51.92	19.29	52.35	19.99	52.42	21.41	6.51
123	1952	50.42	17.36	52.21	18.68	52.72	19.33	52.88	20.71	6.35
124	2000	50.68	16.84	52.50	18.09	53.10	18.70	53.34	20.04	6.20
	$\frac{E_\mu(E)}{f_2}$	302.8		300.2		298.5		291.6		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	138.9		140.1		140.9		144.2		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Pm (61) f_1	Pm (61) f_2	Sm (62) f_1	Sm (62) f_2	Eu (63) f_1	Eu (63) f_2	Gd (64) f_1	Gd (64) f_2	λ(A)
0	100	11.04	4.17	6.55	7.51	14.42	6.27	13.48	8.14	124.0
1	102	10.50	4.23	6.16	7.39	14.14	6.17	13.38	8.07	121.5
2	104	9.82	4.29	5.68	7.28	13.81	6.09	13.25	8.00	119.2
3	107	8.59	4.38	4.85	7.11	13.23	5.96	13.01	7.90	115.9
4	110	7.01	4.87	3.78	7.00	12.34	5.84	12.68	7.80	112.7
5	112	5.81	5.41	2.85	6.96	11.68	6.05	12.39	7.74	110.7
6	115	4.08	6.75	1.27	6.93	10.68	6.37	11.92	7.59	107.8
7	118	2.40	8.41	-0.58	6.91	9.65	6.70	11.29	7.33	105.1
8	121	0.69	10.69	-3.18	7.09	8.39	7.04	10.29	7.08	102.5
9	124	-0.73	13.56	-7.16	7.38	6.70	7.39	8.93	6.85	100.0
10	127	-1.89	17.06	-12.58	8.37	4.09	7.75	7.10	6.62	97.6
11	130	-2.76	21.33	-20.16	13.45	-0.10	8.12	4.56	6.41	95.4
12	133	-2.79	26.94	-25.90	23.61	-5.46	13.71	0.10	6.85	93.2
13	136	0.94	34.17	-26.41	40.93	-6.44	22.89	-4.79	10.69	91.2
14	140	10.13	44.54	-9.22	63.81	0.75	44.57	-10.25	19.09	88.6
15	143	18.86	40.52	6.76	63.69	12.19	39.92	-12.20	29.17	86.7
16	147	25.54	36.01	22.28	56.02	21.11	34.58	-2.16	50.64	84.3
17	150	28.66	33.14	29.06	49.68	24.06	31.13	18.18	57.38	82.7
18	154	31.37	29.68	33.21	42.49	24.91	28.08	30.03	42.09	80.5
19	158	32.85	26.30	35.31	36.48	25.88	26.84	32.92	34.76	78.5
20	162	33.68	23.38	36.37	31.44	26.96	25.70	34.70	28.84	76.5
21	166	34.03	21.03	36.58	27.20	28.00	24.62	35.11	24.04	74.7
22	170	34.11	19.09	35.64	23.61	28.88	23.62	33.87	20.12	72.9
23	174	33.95	17.37	34.77	21.54	29.67	22.68	32.56	18.05	71.3
24	178	33.70	16.17	33.95	19.88	30.35	21.79	31.08	17.02	69.7
25	182	33.54	15.14	33.22	18.38	31.00	20.96	29.99	16.07	68.1
26	187	33.44	13.97	32.35	17.07	31.79	19.99	28.93	16.27	66.3
27	191	33.35	13.04	31.73	16.30	32.32	18.56	28.66	16.86	64.9
28	196	33.07	11.96	31.16	15.42	32.16	17.45	29.37	16.61	63.3
29	201	32.71	11.00	30.62	14.75	32.14	16.67	29.65	15.94	61.7
30	206	32.24	10.13	30.18	14.27	32.12	15.95	29.73	15.31	60.2
31	211	31.69	9.41	29.85	13.81	32.06	15.27	29.66	14.72	58.8
32	216	31.02	8.88	29.58	13.39	31.81	14.72	29.49	14.43	57.4
33	221	30.48	8.69	29.32	12.98	31.65	14.49	29.41	14.23	56.1
34	227	29.95	8.48	29.01	12.52	31.55	14.23	29.40	13.99	54.6
35	232	29.58	8.32	28.69	12.17	31.54	14.02	29.41	13.81	53.4
36	238	29.17	8.26	28.37	12.00	31.57	13.78	29.43	13.60	52.1
37	244	28.83	8.23	28.12	11.83	31.59	13.55	29.46	13.39	50.8
38	250	28.54	8.20	27.93	11.67	31.62	13.32	29.48	13.19	49.6
39	256	28.27	8.18	27.76	11.52	31.64	13.11	29.49	13.00	48.4
40	262	28.04	8.24	27.59	11.37	31.65	12.91	29.49	12.82	47.3
41	269	27.80	8.31	27.38	11.21	31.65	12.68	29.43	12.62	46.1
42	275	27.62	8.37	27.13	11.07	31.62	12.49	29.29	12.45	45.1
43	282	27.41	8.47	26.85	11.08	31.49	12.28	29.15	12.47	44.0
44	289	27.22	8.62	26.62	11.23	31.33	12.14	29.05	12.58	42.9
45	296	27.05	8.78	26.49	11.38	31.16	12.25	29.05	12.69	41.9
46	303	26.90	9.04	26.44	11.53	31.13	12.35	29.09	12.79	40.9
47	311	26.81	9.35	26.41	11.70	31.14	12.47	29.18	12.91	39.9
48	318	26.80	9.64	26.41	11.84	31.18	12.57	29.25	13.01	39.0
49	326	26.83	10.00	26.45	12.00	31.26	12.69	29.38	13.13	38.0
50	334	27.01	10.36	26.50	12.17	31.38	12.80	29.53	13.24	37.1
51	342	27.22	10.62	26.57	12.37	31.51	12.91	29.69	13.35	36.3
52	351	27.48	10.81	26.72	12.63	31.67	13.04	29.88	13.47	35.3
53	359	27.68	10.98	26.95	12.86	31.84	13.15	30.07	13.58	34.5
54	368	27.94	11.18	27.27	13.08	32.05	13.27	30.31	13.70	33.7
55	377	28.23	11.39	27.63	13.12	32.28	13.38	30.57	13.82	32.9
56	386	28.57	11.45	27.94	13.16	32.58	13.50	30.88	13.93	32.1
57	396	28.92	11.50	28.30	13.20	32.97	13.57	31.30	13.99	31.3
58	406	29.24	11.48	28.69	13.12	33.29	13.49	31.63	13.91	30.5
59	415	29.50	11.44	28.97	12.97	33.54	13.42	31.90	13.85	29.9
60	426	29.75	11.38	29.24	12.79	33.82	13.35	32.19	13.77	29.1
61	436	29.96	11.33	29.44	12.64	34.06	13.28	32.44	13.70	28.4
62	447	30.18	11.27	29.61	12.48	34.31	13.20	32.71	13.63	27.7
63	458	30.39	11.21	29.73	12.35	34.55	13.11	32.96	13.54	27.1
64	469	30.57	11.13	29.86	12.26	34.76	13.02	33.18	13.45	26.4

N	E(eV)	Pm (61) Promethium f_1	Pm (61) Promethium f_2	Sm (62) Samarium f_1	Sm (62) Samarium f_2	Eu (63) Europium f_1	Eu (63) Europium f_2	Gd (64) Gadolinium f_1	Gd (64) Gadolinium f_2	λ(A)
65	480	30.74	11.06	29.99	12.18	34.96	12.92	33.39	13.37	25.83
66	492	30.90	10.99	30.13	12.08	35.16	12.82	33.61	13.27	25.20
67	504	31.05	10.91	30.27	11.99	35.35	12.73	33.82	13.18	24.60
68	516	31.19	10.84	30.40	11.91	35.54	12.63	34.03	13.09	24.03
69	529	31.35	10.76	30.55	11.80	35.75	12.52	34.24	12.99	23.44
70	542	31.48	10.65	30.68	11.68	35.92	12.39	34.44	12.87	22.87
71	555	31.61	10.55	30.80	11.55	36.10	12.26	34.63	12.75	22.34
72	569	31.71	10.43	30.90	11.41	36.25	12.11	34.82	12.62	21.79
73	583	31.79	10.31	30.98	11.27	36.38	11.97	34.98	12.47	21.27
74	597	31.85	10.19	31.03	11.13	36.49	11.82	35.12	12.34	20.77
75	612	31.90	10.08	31.09	11.00	36.60	11.68	35.27	12.19	20.26
76	627	31.93	9.96	31.13	10.86	36.69	11.53	35.40	12.05	19.77
77	642	31.96	9.84	31.16	10.72	36.78	11.38	35.53	11.90	19.31
78	658	31.95	9.69	31.15	10.55	36.83	11.20	35.62	11.71	18.84
79	674	31.91	9.55	31.11	10.39	36.86	11.02	35.68	11.53	18.39
80	690	31.83	9.44	31.04	10.27	36.85	10.89	35.71	11.40	17.97
81	707	31.76	9.34	30.98	10.16	36.85	10.77	35.76	11.27	17.54
82	725	31.64	9.18	30.89	9.99	36.83	10.59	35.79	11.09	17.10
83	742	31.49	9.05	30.77	9.84	36.79	10.44	35.80	10.93	16.71
84	760	31.30	8.91	30.61	9.69	36.70	10.28	35.77	10.76	16.31
85	779	31.07	8.76	30.41	9.53	36.60	10.11	35.74	10.59	15.92
86	798	30.77	8.61	30.17	9.37	36.46	9.94	35.66	10.41	15.54
87	818	30.41	8.45	29.85	9.20	36.26	9.76	35.53	10.22	15.16
88	838	29.94	8.30	29.49	9.03	36.02	9.59	35.37	10.05	14.79
89	858	29.41	8.16	29.07	8.88	35.73	9.42	35.19	9.87	14.45
90	879	28.74	8.01	28.52	8.71	35.37	9.24	34.95	9.69	14.10
91	901	27.84	7.85	27.83	8.54	34.90	9.06	34.63	9.51	13.76
92	923	26.76	7.71	27.05	8.38	34.36	8.89	34.27	9.34	13.43
93	945	25.29	7.56	26.06	8.22	33.72	8.72	33.86	9.17	13.12
94	968	23.22	7.41	24.70	8.05	32.84	8.54	33.31	8.99	12.81
95	992	19.18	7.26	22.91	7.89	31.72	8.37	32.63	8.81	12.50
96	1016	10.30 M	7.12	20.57	7.73	30.37	8.20	31.85	8.63	12.20
97	1041	13.67	28.41	16.39	7.56	28.45	8.02	30.84	8.45	11.91
98	1067	20.15	28.47	0.17 M	7.39	25.01	7.85	29.35	8.26	11.62
99	1093	24.29	28.53	4.62	31.65	16.91	7.68	27.49	8.08	11.34
100	1119	27.00	28.58	16.58	31.62	-0.39 M	7.52	24.99	7.91	11.08
101	1147	29.11	28.64	23.01	31.60	14.01	38.05	19.46	7.74	10.81
102	1175	30.96	28.70	26.02	31.57	27.86	36.79	3.02 M	7.57	10.55
103	1204	32.49	28.76	28.35	31.54	33.54	35.55	6.48	37.04	10.30
104	1233	33.91	28.82	30.28	31.52	37.01	34.38	20.07	35.86	10.06
105	1263	35.22	28.88	32.00	31.49	39.97	33.25	30.92	34.70	9 82
106	1294	36.49	28.94	33.56	31.47	42.04	32.14	33.97	33.58	9.58
107	1326	37.73	29.00	35.00	31.45	44.02	31.07	37.13	32.48	9.35
108	1358	38.95	29.06	36.39	31.42	45.50	30.05	39.10	31.45	9.13
109	1392	40.22	29.12	37.75	31.40	46.94	29.04	40.82	30.41	8.91
110	1426	41.58	29.18	39.09	31.37	47.98	28.08	42.17	29.44	8.69
111	1460	43.00	29.24	40.49	31.35	48.96	27.17	42.98	28.51	8.49
112	1496	44.62	29.05	41.95	31.09	49.75	26.28	43.65	27.58	8.29
113	1533	46.14	28.15	42.68	30.13	50.34	25.48	41.86	26.65	8.09
114	1570	47.09	27.30	43.49	31.28	50.08	24.73	42.55	29.81	7.90
115	1609	47.95	26.45	44.76	30.27	49.76	23.97	43.99	28.90	7.71
116	1648	47.69	26.82	46.03	29.31	50.88	24.92	45.42	28.03	7.52
117	1688	49.59	26.01	47.33	28.39	52.20	24.09	47.50	29.07	7.34
118	1730	50.76	25.21	48.85	28.72	53.59	23.27	50.06	28.12	7.17
119	1772	51.55	24.43	50.31	27.83	54.10	22.50	50.90	27.21	7.00
120	1815	52.28	23.66	51.10	26.97	54.91	22.71	51.39	26.34	6.83
121	1860	52.79	22.90	51.79	26.11	55.64	21.98	51.90	25.47	6.67
122	1905	53.28	22.19	52.49	25.30	56.16	21.29	52.82	25.75	6.51
123	1952	53.80	21.48	53.21	24.50	56.65	20.60	54.04	24.91	6.35
124	2000	54.32	20.80	53.95	23.72	57.16	19.94	55.28	24.10	6.20
	$\frac{E\mu(E)}{f_2}$	290.0		279.7		276.8		267.5		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	145.0		150.4		152.0		157.3		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Tb (65)		Dy (66)		Ho (67)		Er (68)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	13.37	8.19	11.80	12.56	13.66	9.08	15.79	10.57	124.0
1	102	13.30	8.21	11.82	12.48	13.69	9.23	15.75	10.28	121.5
2	104	13.22	8.24	11.86	12.40	13.75	9.37	15.64	10.08	119.2
3	107	13.07	8.36	11.88	12.29	13.84	9.58	15.46	9.95	115.9
4	110	12.94	8.48	11.87	12.18	13.98	9.74	15.27	9.82	112.7
5	112	12.91	8.56	11.86	12.11	14.02	9.85	15.10	9.80	110.7
6	115	12.81	8.60	11.77	11.91	14.08	10.01	14.87	9.92	107.8
7	118	12.72	8.62	11.58	11.71	14.14	10.16	14.70	10.04	105.1
8	121	12.61	8.65	11.29	11.52	14.18	10.34	14.58	10.20	102.5
9	124	12.42	8.51	10.89	11.34	14.24	10.52	14.51	10.39	100.0
10	127	12.14	8.21	10.38	11.17	14.36	10.70	14.46	10.58	97.6
11	130	11.64	7.73	9.77	11.03	14.59	10.89	14.42	10.76	95.4
12	133	10.79	7.16	8.92	10.89	14.88	10.71	14.45	10.90	93.2
13	136	9.29	6.15	7.74	10.77	14.92	10.31	14.44	11.01	91.2
14	140	5.94	5.72	5.69	10.66	14.62	9.67	14.41	11.14	88.6
15	143	1.74	5.63	3.50	10.82	13.95	8.89	14.31	11.19	86.7
16	147	-10.06	6.10	-2.46	11.73	12.34	8.17	14.31	11.26	84.3
17	150	-31.90	17.25	-7.71	16.52	10.77	8.02	14.41	11.18	82.7
18	154	3.70	47.53	-9.00	29.10	7.41	8.13	13.97	10.19	80.5
19	158	16.71	40.13	-1.66	41.27	2.06	10.07	12.07	9.31	78.5
20	162	24.24	34.02	12.88	51.32	-0.49	18.30	7.97	8.71	76.5
21	166	27.15	23.14	25.95	41.23	1.09	30.04	2.92	11.68	74.7
22	170	24.34	21.91	29.57	29.91	11.29	37.08	2.14	23.67	72.9
23	174	23.19	21.66	27.66	25.40	20.45	35.27	11.39	34.65	71.3
24	178	23.11	21.89	26.42	23.89	26.42	27.33	22.26	28.13	69.7
25	182	23.92	21.67	25.85	22.99	25.76	22.50	23.10	21.06	68.1
26	187	24.89	21.07	25.56	21.54	24.96	20.94	23.05	18.70	66.3
27	191	25.63	19.97	25.10	20.59	24.61	20.43	22.51	17.04	64.9
28	196	25.65	18.85	24.76	20.26	24.80	19.82	21.70	16.37	63.3
29	201	25.57	18.30	24.68	19.95	25.02	19.25	21.12	15.99	61.7
30	206	25.54	17.99	24.67	19.65	25.23	18.79	20.75	16.10	60.2
31	211	25.58	17.72	24.63	19.37	25.43	18.38	20.57	16.21	58.8
32	216	25.68	17.57	24.70	19.22	25.58	17.98	20.51	16.43	57.4
33	221	25.81	17.42	24.80	19.07	25.70	17.70	20.53	16.68	56.1
34	227	26.01	17.26	24.94	18.90	25.84	17.41	20.66	16.97	54.6
35	232	26.16	17.17	25.05	18.76	25.95	17.18	20.83	17.21	53.4
36	238	26.35	17.11	25.11	18.60	26.01	16.91	21.07	17.50	52.1
37	244	26.59	17.05	25.17	18.53	26.01	16.74	21.34	17.78	50.8
38	250	26.84	16.99	25.26	18.55	25.97	16.65	21.63	18.06	49.6
39	256	27.09	16.93	25.40	18.56	25.88	16.61	21.95	18.34	48.4
40	262	27.35	16.87	25.54	18.57	25.88	16.82	22.30	18.62	47.3
41	269	27.64	16.81	25.69	18.59	25.96	17.07	22.76	18.94	46.1
42	275	27.89	16.76	25.80	18.60	26.12	17.28	23.22	19.21	45.1
43	282	28.19	16.70	25.86	18.76	26.36	17.53	23.79	19.36	44.0
44	289	28.48	16.64	26.05	19.02	26.65	17.76	24.31	19.45	42.9
45	296	28.77	16.58	26.30	19.28	26.97	17.97	24.79	19.54	41.9
46	303	29.07	16.53	26.60	19.53	27.32	18.18	25.24	19.62	40.9
47	311	29.42	16.46	27.00	19.83	27.79	18.42	25.74	19.72	39.9
48	318	29.72	16.35	27.44	20.09	28.28	18.50	26.19	19.80	39.0
49	326	30.04	16.24	27.96	20.39	28.77	18.50	26.70	19.89	38.0
50	334	30.33	16.13	28.61	20.68	29.18	18.50	27.28	19.98	37.1
51	342	30.62	16.02	29.44	20.97	29.57	18.50	27.87	20.00	36.3
52	351	30.94	15.91	30.47	20.91	30.00	18.50	28.52	19.81	35.3
53	359	31.22	15.81	31.40	20.80	30.36	18.50	28.95	19.64	34.5
54	368	31.55	15.70	32.37	20.24	30.75	18.50	29.37	19.46	33.7
55	377	31.88	15.48	33.05	19.37	31.13	18.50	29.75	19.29	32.9
56	386	32.15	15.27	33.40	18.56	31.52	18.50	30.06	19.17	32.1
57	396	32.41	15.04	33.27	17.95	31.94	18.50	30.36	19.06	31.3
58	406	32.62	14.82	33.26	17.67	32.36	18.50	30.68	19.04	30.5
59	415	32.79	14.64	33.29	17.58	32.74	18.50	30.97	19.02	29.9
60	426	32.95	14.41	33.46	17.54	33.24	18.50	31.36	18.99	29.1
61	436	33.08	14.26	33.70	17.51	33.72	18.47	31.70	18.97	28.4
62	447	33.21	14.12	34.04	17.47	34.25	18.27	32.08	18.95	27.7
63	458	33.35	13.98	34.46	17.32	34.67	18.08	32.45	18.93	27.1
64	469	33.47	13.85	34.79	17.04	35.01	17.90	32.83	18.90	26.4

N	E(eV)	Tb (65) Terbium f_1	Tb (65) Terbium f_2	Dy (66) Dysprosium f_1	Dy (66) Dysprosium f_2	Ho (67) Holmium f_1	Ho (67) Holmium f_2	Er (68) Erbium f_1	Er (68) Erbium f_2	λ(A)
65	480	33.59	13.73	35.06	16.77	35.34	17.74	33.22	18.88	25.83
66	492	33.67	13.60	35.29	16.49	35.71	17.64	33.65	18.86	25.20
67	504	33.74	13.54	35.45	16.25	36.08	17.46	34.12	18.80	24.60
68	516	33.85	13.54	35.63	16.09	36.43	17.29	34.59	18.69	24.03
69	529	34.02	13.51	35.83	15.91	36.77	17.10	35.06	18.54	23.44
70	542	34.19	13.43	36.05	15.74	37.10	16.89	35.50	18.33	22.87
71	555	34.35	13.36	36.24	15.57	37.41	16.70	35.89	18.13	22.34
72	569	34.51	13.29	36.45	15.37	37.72	16.47	36.30	17.89	21.79
73	583	34.65	13.21	36.66	15.16	37.99	16.25	36.65	17.65	21.27
74	597	34.79	13.14	36.83	14.97	38.24	16.04	36.97	17.41	20.77
75	612	34.94	13.07	37.01	14.76	38.50	15.83	37.29	17.16	20.26
76	627	35.08	13.00	37.18	14.57	38.74	15.62	37.59	16.93	19.77
77	642	35.23	12.93	37.36	14.36	38.99	15.40	37.89	16.68	19.31
78	658	35.38	12.86	37.50	14.10	39.20	15.14	38.14	16.36	18.84
79	674	35.57	12.79	37.58	13.86	39.37	14.88	38.36	16.06	18.39
80	690	35.75	12.65	37.66	13.68	39.52	14.70	38.52	15.84	17.97
81	707	35.92	12.49	37.76	13.50	39.73	14.51	38.73	15.63	17.54
82	725	36.03	12.28	37.85	13.27	39.90	14.23	38.94	15.34	17.10
83	742	36.12	12.08	37.92	13.05	40.04	13.99	39.10	15.08	16.71
84	760	36.17	11.89	37.97	12.84	40.14	13.74	39.24	14.81	16.31
85	779	36.20	11.69	38.01	12.62	40.24	13.48	39.36	14.54	15.92
86	798	36.19	11.47	38.02	12.38	40.31	13.22	39.47	14.26	15.54
87	818	36.14	11.26	38.00	12.13	40.35	12.96	39.54	13.98	15.16
88	838	36.05	11.05	37.94	11.90	40.36	12.71	39.59	13.71	14.79
89	858	35.93	10.85	37.86	11.67	40.36	12.47	39.62	13.45	14.45
90	879	35.79	10.64	37.74	11.44	40.33	12.22	39.62	13.18	14.10
91	901	35.57	10.43	37.58	11.21	40.26	11.97	39.59	12.92	13.76
92	923	35.32	10.23	37.38	10.98	40.16	11.74	39.54	12.66	13.43
93	945	35.03	10.03	37.15	10.76	40.04	11.50	39.46	12.40	13.12
94	968	34.62	9.82	36.88	10.53	39.87	11.25	39.32	12.13	12.81
95	992	34.15	9.62	36.51	10.31	39.65	11.01	39.15	11.87	12.50
96	1016	33.61	9.42	36.10	10.09	39.40	10.78	38.96	11.61	12.20
97	1041	32.90	9.21	35.61	9.86	39.08	10.53	38.70	11.33	11.91
98	1067	31.95	9.00	34.96	9.63	38.65	10.27	38.34	11.05	11.62
99	1093	30.89	8.80	34.17	9.40	38.15	10.03	37.93	10.79	11.34
100	1119	29.40	8.60	33.24	9.19	37.57	9.80	37.46	10.53	11.08
101	1147	27.25	8.41	32.06	8.97	36.78	9.56	36.81	10.27	10.81
102	1175	24.55	8.22	30.41	8.77	35.84	9.33	36.07	10.02	10.55
103	1204	18.98	8.04	28.10	8.56	34.60	9.11	35.14	9.78	10.30
104	1233	0.26 M	7.86	24.93	8.37	33.08	8.90	34.00	9.54	10.06
105	1263	13.86	38.62	18.98	8.17	30.83	8.69	32.51	9.32	9.82
106	1294	23.63	37.30	-8.26 M	7.99	26.71	8.49	30.36	9.09	9.58
107	1326	31.62	36.01	10.76	38.40	19.73	8.28	27.54	8.87	9.35
108	1358	34.81	34.79	23.35	37.10	2.64 M	37.99	21.52	8.66	9.13
109	1392	38.21	33.57	34.03	35.79	16.12	36.66	1.40 M	8.45	8.91
110	1426	39.98	32.42	36.86	34.56	29.61	35.41	9.98	39.93	8.69
111	1460	41.70	31.34	39.69	33.40	37.64	34.22	23.22	38.60	8.49
112	1496	43.02	30.26	41.83	32.24	40.73	33.04	34.31	37.27	8.29
113	1533	43.73	29.21	43.18	31.13	43.06	31.90	37.69	35.99	8.09
114	1570	43.68	28.22	44.48	30.07	44.48	30.83	41.07	34.78	7.90
115	1609	41.62	27.24	43.74	29.03	45.93	29.76	42.94	33.58	7.71
116	1648	43.75	30.83	43.01	28.04	46.82	28.75	44.75	32.45	7.52
117	1688	45.95	29.84	43.16	31.64	46.82	27.78	45.97	31.36	7.34
118	1730	48.25	28.85	47.36	30.64	46.82	26.82	46.90	30.27	7.17
119	1772	48.09	29.93	49.07	29.70	45.43	30.12	46.48	29.25	7.00
120	1815	49.60	28.95	50.03	28.78	47.16	29.14	44.35	33.02	6.83
121	1860	51.18	27.98	51.50	29.68	48.97	28.16	46.34	31.85	6.67
122	1905	52.76	27.07	52.25	28.70	50.78	27.24	48.34	30.75	6.51
123	1952	54.41	26.16	53.05	27.74	52.53	28.14	50.42	29.67	6.35
124	2000	55.16	26.39	53.85	26.81	54.27	27.18	52.55	28.62	6.20
	$\frac{E\rho(E)}{f_2}$	264.6		258.8		255.0		251.4		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	158.9		162.5		164.9		167.3		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Tm (69) f_1	Tm (69) f_2	Yb (70) f_1	Yb (70) f_2	Lu (71) f_1	Lu (71) f_2	Hf (72) f_1	Hf (72) f_2	λ(A)
0	100	12.50	11.59	10.11	11.32	11.13	8.70	10.63	8.93	124.0
1	102	12.68	11.58	10.18	11.48	10.85	8.99	10.59	9.08	121.5
2	104	12.81	11.56	10.25	11.64	10.73	9.28	10.59	9.23	119.2
3	107	12.98	11.52	10.38	11.87	10.65	9.73	10.62	9.46	115.9
4	110	13.12	11.49	10.56	12.10	10.68	10.12	10.64	9.69	112.7
5	112	13.18	11.47	10.73	12.25	10.69	10.33	10.65	9.85	110.7
6	115	13.25	11.45	10.95	12.44	10.74	10.64	10.67	10.08	107.8
7	118	13.30	11.43	11.19	12.52	10.80	10.97	10.66	10.30	105.1
8	121	13.31	11.41	11.35	12.60	10.84	11.29	10.60	10.56	102.5
9	124	13.33	11.48	11.44	12.68	10.91	11.62	10.57	10.91	100.0
10	127	13.34	11.55	11.51	12.75	11.00	11.94	10.57	11.26	97.6
11	130	13.34	11.62	11.56	12.83	11.10	12.27	10.61	11.62	95.4
12	133	13.34	11.69	11.47	12.95	11.23	12.60	10.66	11.98	93.2
13	136	13.34	11.77	11.44	13.28	11.36	12.93	10.76	12.36	91.2
14	140	13.29	11.87	11.52	13.71	11.55	13.37	10.89	12.87	88.6
15	143	13.27	11.95	11.65	14.04	11.72	13.70	11.04	13.26	86.7
16	147	13.15	12.06	11.91	14.47	12.01	14.15	11.31	13.79	84.3
17	150	13.08	12.15	12.19	14.80	12.27	14.45	11.56	14.15	82.7
18	154	13.05	12.18	12.60	14.83	12.62	14.75	11.92	14.50	80.5
19	158	12.95	11.88	12.70	14.70	12.84	15.02	12.22	14.82	78.5
20	162	12.01	11.04	12.58	14.56	13.09	15.28	12.47	15.14	76.5
21	166	7.97	9.48	11.95	14.43	13.34	15.55	12.70	15.46	74.7
22	170	-1.75	8.45	8.98	14.31	13.60	15.81	12.95	15.78	72.9
23	174	3.54	32.92	10.46	23.04	13.83	16.07	13.22	16.09	71.3
24	178	15.70	27.46	14.76	20.64	14.11	16.34	13.49	16.41	69.7
25	182	19.76	23.01	15.51	18.53	14.33	16.60	13.78	16.73	68.1
26	187	19.53	19.59	15.81	17.88	14.60	16.92	14.14	17.12	66.3
27	191	19.03	18.87	15.53	17.91	14.77	17.16	14.45	17.43	64.9
28	196	19.15	18.47	15.60	18.19	14.97	17.62	14.92	17.76	63.3
29	201	19.15	18.10	15.90	18.57	15.34	18.15	15.31	18.06	61.7
30	206	19.14	18.07	16.30	18.96	15.83	18.68	15.71	18.36	60.2
31	211	19.13	18.18	16.75	19.35	16.44	19.21	16.13	18.66	58.8
32	216	19.43	18.29	17.33	19.49	17.21	19.38	16.58	18.88	57.4
33	221	19.71	18.41	17.86	19.55	17.75	19.45	16.99	19.08	56.1
34	227	20.06	18.55	18.39	19.62	18.33	19.52	17.45	19.32	54.6
35	232	20.37	18.66	18.78	19.68	18.77	19.58	17.82	19.52	53.4
36	238	20.78	18.77	19.21	19.75	19.23	19.64	18.26	19.75	52.1
37	244	21.17	18.85	19.62	19.82	19.66	19.71	18.70	19.98	50.8
38	250	21.56	18.93	20.01	19.89	20.07	19.78	19.13	20.21	49.6
39	256	21.96	19.00	20.39	19.96	20.46	19.84	19.57	20.43	48.4
40	262	22.38	19.06	20.74	20.02	20.81	19.91	20.02	20.65	47.3
41	269	22.84	19.04	21.13	20.10	21.18	19.98	20.59	20.90	46.1
42	275	23.19	19.02	21.44	20.16	21.48	20.04	21.12	21.12	45.1
43	282	23.58	19.00	21.77	20.28	21.80	20.18	21.73	21.21	44.0
44	289	23.96	18.97	22.13	20.42	22.14	20.36	22.29	21.23	42.9
45	296	24.31	18.93	22.50	20.55	22.48	20.53	22.79	21.25	41.9
46	303	24.62	18.89	22.86	20.69	22.84	20.70	23.24	21.27	40.9
47	311	24.92	18.84	23.26	20.84	23.27	20.89	23.74	21.29	39.9
48	318	25.20	18.80	23.66	20.97	23.64	21.05	24.13	21.31	39.0
49	326	25.47	18.76	24.09	21.11	24.06	21.23	24.57	21.33	38.0
50	334	25.63	18.72	24.51	21.25	24.49	21.41	24.97	21.35	37.1
51	342	25.83	18.86	24.94	21.39	24.92	21.59	25.37	21.37	36.3
52	351	26.09	19.03	25.44	21.55	25.41	21.79	25.79	21.40	35.3
53	359	26.36	19.17	25.88	21.68	25.86	21.96	26.14	21.42	34.5
54	368	26.70	19.33	26.39	21.83	26.39	22.15	26.52	21.44	33.7
55	377	27.04	19.48	26.92	21.98	26.94	22.34	26.86	21.46	32.9
56	386	27.39	19.62	27.50	22.12	27.52	22.52	27.16	21.48	32.1
57	396	27.79	19.76	28.22	22.19	28.32	22.65	27.37	21.51	31.3
58	406	28.24	19.90	28.87	22.05	28.98	22.53	27.62	21.84	30.5
59	415	28.64	20.02	29.37	21.94	29.52	22.43	27.93	22.13	29.9
60	426	29.16	20.16	29.90	21.80	30.07	22.31	28.43	22.48	29.1
61	436	29.62	20.21	30.33	21.67	30.52	22.21	28.97	22.80	28.4
62	447	30.12	20.27	30.76	21.54	30.96	22.10	29.65	23.15	27.7
63	458	30.63	20.32	31.11	21.49	31.32	22.08	30.54	23.25	27.1
64	469	31.15	20.33	31.51	21.51	31.74	22.13	31.23	23.13	26.4

N	E(eV)	Tm (69) Thulium f_1	Tm (69) Thulium f_2	Yb (70) Ytterbium f_1	Yb (70) Ytterbium f_2	Lu (71) Lutetium f_1	Lu (71) Lutetium f_2	Hf (72) Hafnium f_1	Hf (72) Hafnium f_2	λ(A)
65	480	31.64	20.32	31.93	21.53	32.19	22.19	31.83	23.01	25.83
66	492	32.17	20.30	32.41	21.54	32.71	22.26	32.39	22.88	25.20
67	504	32.71	20.27	32.93	21.56	33.25	22.32	32.87	22.76	24.60
68	516	33.25	20.20	33.49	21.58	33.87	22.38	33.27	22.65	24.03
69	529	33.85	20.08	34.17	21.51	34.63	22.34	33.58	22.67	23.44
70	542	34.42	19.84	34.77	21.27	35.34	22.09	34.09	23.01	22.87
71	555	34.88	19.61	35.29	21.04	35.94	21.85	34.93	23.34	22.34
72	569	35.36	19.35	35.86	20.76	36.49	21.56	35.89	23.07	21.79
73	583	35.78	19.08	36.33	20.48	36.98	21.28	36.60	22.76	21.27
74	597	36.17	18.83	36.74	20.21	37.44	21.01	37.19	22.46	20.77
75	612	36.54	18.57	37.17	19.93	37.90	20.73	37.76	22.15	20.26
76	627	36.91	18.31	37.57	19.65	38.34	20.46	38.30	21.85	19.77
77	642	37.26	18.05	37.98	19.37	38.77	20.17	38.83	21.54	19.31
78	658	37.57	17.72	38.33	19.01	39.17	19.81	39.28	21.17	18.84
79	674	37.80	17.40	38.61	18.66	39.53	19.47	39.68	20.81	18.39
80	690	38.05	17.17	38.87	18.41	39.78	19.22	40.04	20.55	17.97
81	707	38.32	16.94	39.17	18.16	40.14	18.97	40.46	20.29	17.54
82	725	38.59	16.62	39.48	17.83	40.49	18.62	40.89	19.90	17.10
83	742	38.81	16.33	39.72	17.53	40.79	18.30	41.23	19.56	16.71
84	760	39.00	16.04	39.96	17.23	41.06	17.98	41.55	19.20	16.31
85	779	39.20	15.74	40.20	16.92	41.32	17.64	41.86	18.84	15.92
86	798	39.34	15.42	40.41	16.58	41.56	17.29	42.13	18.49	15.54
87	818	39.47	15.10	40.58	16.24	41.77	16.94	42.38	18.12	15.16
88	838	39.56	14.80	40.73	15.91	41.94	16.60	42.60	17.78	14.79
89	858	39.62	14.50	40.86	15.59	42.10	16.27	42.81	17.45	14.45
90	879	39.67	14.20	40.95	15.26	42.22	15.94	43.00	17.10	14.10
91	901	39.68	13.91	41.03	14.94	42.33	15.60	43.16	16.76	13.76
92	923	39.67	13.62	41.08	14.62	42.42	15.29	43.31	16.44	13.43
93	945	39.64	13.34	41.11	14.31	42.48	14.97	43.45	16.10	13.12
94	968	39.58	13.06	41.09	13.99	42.52	14.65	43.55	15.75	12.81
95	992	39.48	12.78	41.06	13.67	42.54	14.34	43.63	15.41	12.50
96	1016	39.35	12.51	40.99	13.36	42.55	14.03	43.69	15.08	12.20
97	1041	39.18	12.21	40.90	13.03	42.52	13.69	43.72	14.71	11.91
98	1067	38.94	11.90	40.74	12.70	42.43	13.34	43.70	14.34	11.62
99	1093	38.64	11.61	40.54	12.38	42.29	13.01	43.64	13.99	11.34
100	1119	38.29	11.33	40.29	12.08	42.12	12.70	43.56	13.66	11.08
101	1147	37.85	11.05	39.96	11.77	41.90	12.37	43.40	13.32	10.81
102	1175	37.31	10.78	39.60	11.48	41.61	12.07	43.22	12.99	10.55
103	1204	36.67	10.51	39.14	11.19	41.28	11.77	42.99	12.67	10.30
104	1233	35.94	10.26	38.61	10.91	40.90	11.48	42.71	12.36	10.06
105	1263	35.01	10.01	37.97	10.64	40.43	11.20	42.37	12.06	9.82
106	1294	33.78	9.77	37.17	10.37	39.83	10.92	41.96	11.77	9.58
107	1326	32.25	9.52	36.22	10.11	39.14	10.65	41.48	11.47	9.35
108	1358	30.33	9.29	34.99	9.86	38.33	10.39	40.89	11.20	9.13
109	1392	27.03	9.06	33.36	9.61	37.24	10.13	40.17	10.92	8.91
110	1426	18.85 M	8.84	31.32	9.37	35.90	9.88	39.33	10.65	8.69
111	1460	1.30 M	8.63	28.11	9.14	34.32	9.64	38.29	10.40	8.49
112	1496	13.50	28.17	20.84	8.91	31.95	9.39	36.96	10.13	8.29
113	1533	18.05	40.91	3.84 M	28.35	27.49	9.13	35.08	9.84	8.09
114	1570	27.62	39.52	9.98	27.19	18.07	8.88	32.67	9.56	7.90
115	1609	36.27	38.14	22.53	39.28	10.49 M	27.88	27.82	9.29	7.71
116	1648	38.70	36.84	31.92	38.07	21.62	40.70	15.54 M	9.03	7.52
117	1688	41.20	35.58	37.78	36.89	29.01	39.33	12.45	27.94	7.34
118	1730	43.82	34.33	40.85	35.72	36.77	37.97	24.95	40.50	7.17
119	1772	45.37	33.16	42.85	34.62	40.50	36.69	30.67	39.15	7.00
120	1815	45.42	32.03	44.54	33.55	41.81	35.46	33.63	37.85	6.83
121	1860	45.22	30.91	45.54	32.49	43.18	34.24	36.73	36.56	6.67
122	1905	46.43	35.05	44.75	31.49	44.56	33.09	39.82	35.34	6.51
123	1952	48.61	33.80	44.48	35.73	45.99	31.96	43.06	34.15	6.35
124	2000	50.83	32.60	48.18	34.46	47.45	30.87	46.36	32.99	6.20
	$\frac{E\mu(E)}{f_2}$	249.0		243.0		240.4		235.6		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	168.9		173.0		175.0		178.5		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Ta (73) f_1	Ta (73) f_2	W (74) f_1	W (74) f_2	Re (75) f_1	Re (75) f_2	Os (76) f_1	Os (76) f_2	λ(A)
0	100	10.75	9.75	12.58	9.06	15.48	7.16	13.73	7.59	124.0
1	102	10.77	9.91	12.44	9.20	15.20	7.21	13.60	7.73	121.5
2	104	10.78	10.06	12.36	9.34	14.82	7.26	13.43	7.88	119.2
3	107	10.79	10.30	12.29	9.55	14.31	7.51	13.23	8.09	115.9
4	110	10.87	10.53	12.28	9.75	13.99	7.82	12.98	8.31	112.7
5	112	10.88	10.68	12.30	9.89	13.86	8.03	12.85	8.56	110.7
6	115	10.94	10.91	12.32	10.10	13.68	8.35	12.72	8.95	107.8
7	118	11.02	11.14	12.39	10.30	13.56	8.67	12.67	9.36	105.1
8	121	11.08	11.36	12.53	10.50	13.48	9.00	12.67	9.77	102.5
9	124	11.14	11.59	12.82	10.71	13.44	9.33	12.70	10.19	100.0
10	127	11.19	11.82	13.07	10.89	13.43	9.64	12.83	10.61	97.6
11	130	11.22	12.07	13.14	11.03	13.44	9.89	13.07	11.05	95.4
12	133	11.32	12.32	12.58	11.18	13.43	10.15	13.43	11.22	93.2
13	136	11.42	12.57	11.99	11.32	13.45	10.40	13.56	11.37	91.2
14	140	11.58	12.90	11.46	11.51	13.46	10.75	13.77	11.56	88.6
15	143	11.66	13.15	11.24	11.65	13.46	11.00	13.91	11.70	86.7
16	147	11.80	13.48	11.22	11.84	13.51	11.35	14.05	11.89	84.3
17	150	11.92	13.73	11.27	12.09	13.54	11.61	14.14	12.03	82.7
18	154	12.10	14.06	11.37	12.54	13.60	11.96	14.26	12.21	80.5
19	158	12.30	14.38	11.45	12.97	13.70	12.30	14.36	12.39	78.5
20	162	12.47	14.67	11.54	13.41	13.78	12.57	14.44	12.57	76.5
21	166	12.62	14.94	11.63	13.84	13.81	12.82	14.50	12.75	74.7
22	170	12.73	15.21	11.75	14.29	13.78	13.07	14.54	12.93	72.9
23	174	12.83	15.54	11.86	14.73	13.69	13.45	14.49	13.11	71.3
24	178	12.99	15.92	11.99	15.16	13.65	13.93	14.46	13.45	69.7
25	182	13.21	16.29	12.13	15.61	13.63	14.43	14.48	13.80	68.1
26	187	13.46	16.76	12.40	16.18	13.77	15.08	14.50	14.23	66.3
27	191	13.74	17.14	12.70	16.64	13.97	15.61	14.55	14.57	64.9
28	196	14.13	17.53	13.06	17.11	14.32	16.14	14.66	15.00	63.3
29	201	14.51	17.88	13.43	17.52	14.60	16.60	14.74	15.46	61.7
30	206	14.87	18.23	13.79	17.93	14.88	17.06	14.93	15.97	60.2
31	211	15.22	18.57	14.16	18.34	15.21	17.53	15.16	16.49	58.8
32	216	15.66	18.86	14.51	18.69	15.51	17.95	15.50	16.90	57.4
33	221	16.02	19.12	14.87	19.03	15.79	18.36	15.78	17.27	56.1
34	227	16.44	19.43	15.28	19.43	16.14	18.85	16.08	17.71	54.6
35	232	16.80	19.69	15.62	19.77	16.45	19.26	16.31	18.08	53.4
36	238	17.22	19.99	16.06	20.16	16.87	19.75	16.63	18.52	52.1
37	244	17.64	20.30	16.48	20.56	17.29	20.24	16.98	18.96	50.8
38	250	18.07	20.60	16.92	20.95	17.72	20.73	17.33	19.40	49.6
39	256	18.53	20.89	17.38	21.34	18.16	21.22	17.68	19.83	48.4
40	262	18.98	21.19	17.87	21.73	18.67	21.71	18.08	20.27	47.3
41	269	19.57	21.53	18.52	22.19	19.37	22.29	18.60	20.78	46.1
42	275	20.12	21.82	19.13	22.57	20.04	22.78	19.09	21.22	45.1
43	282	20.81	21.95	19.94	22.75	20.92	23.02	19.71	21.54	44.0
44	289	21.41	22.00	20.60	22.83	21.65	23.13	20.28	21.79	42.9
45	296	21.95	22.05	21.18	22.90	22.29	23.23	20.78	22.03	41.9
46	303	22.43	22.10	21.72	22.98	22.89	23.34	21.24	22.26	40.9
47	311	22.96	22.15	22.28	23.06	23.48	23.45	21.77	22.53	39.9
48	318	23.38	22.20	22.75	23.13	24.00	23.55	22.21	22.76	39.0
49	326	23.84	22.25	23.26	23.21	24.56	23.67	22.72	23.02	38.0
50	334	24.28	22.31	23.75	23.29	25.09	23.78	23.22	23.28	37.1
51	342	24.70	22.36	24.20	23.36	25.62	23.89	23.71	23.54	36.3
52	351	25.16	22.41	24.70	23.44	26.19	24.01	24.26	23.82	35.3
53	359	25.54	22.46	25.12	23.52	26.68	24.11	24.76	24.07	34.5
54	368	25.94	22.51	25.57	23.60	27.22	24.22	25.35	24.34	33.7
55	377	26.32	22.56	25.98	23.67	27.77	24.34	25.95	24.61	32.9
56	386	26.67	22.62	26.37	23.75	28.31	24.45	26.57	24.88	32.1
57	396	26.94	22.69	26.70	23.85	28.98	24.54	27.41	25.11	31.3
58	406	27.25	23.02	27.08	24.19	29.56	24.50	28.13	25.07	30.5
59	415	27.60	23.32	27.48	24.50	30.04	24.46	28.70	25.03	29.9
60	426	28.15	23.68	28.05	24.87	30.56	24.41	29.28	24.98	29.1
61	436	28.73	24.01	28.66	25.20	30.95	24.37	29.73	24.94	28.4
62	447	29.49	24.36	29.46	25.56	31.28	24.32	30.12	24.90	27.7
63	458	30.40	24.47	30.37	25.69	31.53	24.46	30.39	25.05	27.1
64	469	31.12	24.36	31.18	25.60	31.89	24.76	30.80	25.36	26.4

N	E(eV)	Ta (73) Tantalum f_1	Ta (73) Tantalum f_2	W (74) Tungsten f_1	W (74) Tungsten f_2	Re (75) Rhenium f_1	Re (75) Rhenium f_2	Os (76) Osmium f_1	Os (76) Osmium f_2	λ(A)
65	480	31.77	24.25	31.87	25.52	32.34	25.05	31.28	25.67	25.83
66	492	32.40	24.14	32.57	25.44	32.90	25.37	31.88	26.00	25.20
67	504	32.97	24.03	33.23	25.35	33.54	25.69	32.56	26.33	24.60
68	516	33.51	23.92	33.86	25.27	34.33	26.00	33.36	26.65	24.03
69	529	34.05	23.77	34.56	25.14	35.31	26.16	34.36	26.84	23.44
70	542	34.51	23.56	35.20	24.91	36.22	25.94	35.31	26.69	22.87
71	555	34.63	23.35	35.75	24.70	36.91	25.73	36.11	26.55	22.34
72	569	35.19	24.20	36.20	24.44	37.46	25.45	36.83	26.36	21.79
73	583	36.31	24.21	36.61	24.39	37.91	25.45	37.56	26.15	21.27
74	597	37.12	23.89	37.07	24.40	38.47	25.55	38.16	25.92	20.77
75	612	37.84	23.56	37.68	24.42	39.18	25.66	38.73	25.69	20.26
76	627	38.47	23.24	38.39	24.44	40.01	25.76	39.21	25.47	19.77
77	642	39.05	22.91	39.17	24.33	41.01	25.69	39.55	25.38	19.31
78	658	39.56	22.52	39.92	23.92	41.87	25.20	40.15	25.59	18.84
79	674	40.02	22.15	40.50	23.52	42.55	24.73	40.93	25.79	18.39
80	690	40.43	21.88	40.99	23.23	43.12	24.39	41.89	25.54	17.97
81	707	40.92	21.61	41.54	22.94	43.72	24.06	42.67	25.18	17.54
82	725	41.38	21.22	42.06	22.54	44.30	23.64	43.36	24.78	17.10
83	742	41.77	20.87	42.52	22.18	44.80	23.27	43.96	24.41	16.71
84	760	42.14	20.50	42.96	21.81	45.30	22.89	44.52	24.04	16.31
85	779	42.50	20.14	43.41	21.43	45.79	22.49	45.09	23.65	15.92
86	798	42.83	19.76	43.79	21.01	46.23	22.07	45.60	23.24	15.54
87	818	43.14	19.38	44.15	20.60	46.65	21.65	46.08	22.82	15.16
88	838	43.41	19.02	44.47	20.20	47.03	21.25	46.52	22.42	14.79
89	858	43.66	18.66	44.76	19.81	47.39	20.86	46.94	22.03	14.45
90	879	43.89	18.30	45.03	19.41	47.73	20.45	47.35	21.62	14.10
91	901	44.11	17.93	45.29	19.01	48.05	20.05	47.72	21.20	13.76
92	923	44.31	17.57	45.52	18.62	48.34	19.66	48.07	20.80	13.43
93	945	44.48	17.21	45.71	18.24	48.62	19.28	48.41	20.38	13.12
94	968	44.63	16.83	45.89	17.86	48.88	18.88	48.71	19.95	12.81
95	992	44.75	16.45	46.05	17.47	49.13	18.49	48.98	19.52	12.50
96	1016	44.84	16.09	46.19	17.10	49.36	18.10	49.24	19.11	12.20
97	1041	44.91	15.71	46.30	16.71	49.57	17.68	49.48	18.67	11.91
98	1067	44.92	15.32	46.38	16.30	49.75	17.26	49.67	18.22	11.62
99	1093	44.90	14.95	46.41	15.92	49.88	16.86	49.82	17.79	11.34
100	1119	44.86	14.60	46.42	15.56	50.00	16.47	49.95	17.38	11.08
101	1147	44.78	14.24	46.39	15.18	50.10	16.07	50.05	16.96	10.81
102	1175	44.66	13.90	46.34	14.82	50.16	15.70	50.12	16.56	10.55
103	1204	44.49	13.56	46.25	14.47	50.20	15.32	50.16	16.17	10.30
104	1233	44.31	13.24	46.14	14.13	50.23	14.97	50.20	15.79	10.06
105	1263	44.08	12.92	46.00	13.79	50.24	14.61	50.21	15.42	9.82
106	1294	43.75	12.58	45.79	13.43	50.21	14.23	50.16	15.03	9.58
107	1326	43.38	12.24	45.52	13.08	50.15	13.86	50.10	14.66	9.35
108	1358	42.92	11.93	45.20	12.74	50.05	13.50	49.99	14.30	9.13
109	1392	42.34	11.60	44.80	12.40	49.91	13.15	49.84	13.93	8.91
110	1426	41.67	11.30	44.30	12.08	49.73	12.81	49.67	13.59	8.69
111	1460	40.91	11.01	43.74	11.77	49.52	12.48	49.46	13.26	8.49
112	1496	39.91	10.72	43.07	11.46	49.26	12.16	49.19	12.93	8.29
113	1533	38.56	10.43	42.18	11.15	48.94	11.84	48.84	12.59	8.09
114	1570	36.96	10.15	41.12	10.85	48.57	11.53	48.46	12.28	7.90
115	1609	34.72	9.87	39.78	10.56	48.13	11.23	47.97	11.96	7.71
116	1648	31.06	9.61	38.04	10.28	47.61	10.94	47.39	11.66	7.52
117	1688	21.81	9.35	35.44	10.00	47.01	10.65	46.72	11.36	7.34
118	1730	3.52 M	9.09	31.84	9.73	46.31	10.37	45.88	11.07	7.17
119	1772	19.99	27.67	24.75	9.46	45.48	10.09	44.81	10.78	7.00
120	1815	33.26	39.83	6.94 M	27.91	44.62	9.82	43.46	10.49	6.83
121	1860	38.71	38.49	15.08	27.29	43.33	9.55	41.75	10.21	6.67
122	1905	43.16	37.22	23.22	39.24	42.35 M	27.66	39.29	9.93	6.51
123	1952	45.33	35.97	31.72	37.94	37.63	39.47	36.41 M	9.67	6.35
124	2000	47.54	34.76	40.40	36.69	32.82	38.21	30.41	27.26	6.20
	$\frac{E\mu(E)}{f_2}$	232.4		228.8		225.9		221.1		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	180.9		183.9		186.2		190.2		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Ir (77) f_1	Ir (77) f_2	Pt (78) f_1	Pt (78) f_2	Au (79) f_1	Au (79) f_2	Hg (80) f_1	Hg (80) f_2	λ(A)
0	100	12.52	7.72	17.74	8.93	22.40	11.15	20.37	23.79	124.0
1	102	12.48	7.90	17.52	8.60	22.45	10.37	21.60	22.96	121.5
2	104	12.45	8.08	17.31	8.28	22.25	9.67	22.70	22.21	119.2
3	107	12.45	8.34	17.01	7.89	21.92	8.94	24.01	20.28	115.9
4	110	12.54	8.61	16.72	7.61	21.68	8.40	24.44	18.29	112.7
5	112	12.63	8.74	16.51	7.43	21.52	7.92	24.41	17.29	110.7
6	115	12.67	8.94	16.16	7.25	21.20	7.27	24.46	16.11	107.8
7	118	12.81	9.14	15.82	7.13	20.75	6.67	24.48	14.81	105.1
8	121	13.01	9.23	15.47	7.01	20.19	6.21	24.27	13.41	102.5
9	124	13.09	9.14	15.05	6.93	19.67	5.94	23.77	12.45	100.0
10	127	13.02	9.04	14.69	7.03	19.17	5.71	23.40	11.72	97.6
11	130	12.79	8.95	14.37	7.12	18.68	5.51	23.07	10.84	95.4
12	133	12.51	9.29	14.07	7.22	18.20	5.38	22.62	10.00	93.2
13	136	12.39	9.62	13.73	7.33	17.69	5.29	21.99	9.22	91.2
14	140	12.30	10.08	13.32	7.68	17.02	5.26	21.06	8.46	88.6
15	143	12.33	10.39	13.07	7.94	16.53	5.36	20.35	8.09	86.7
16	147	12.48	10.80	12.76	8.31	15.97	5.50	19.51	7.71	84.3
17	150	12.58	11.11	12.59	8.58	15.55	5.60	18.88	7.48	82.7
18	154	12.77	11.28	12.37	8.95	14.99	5.88	18.02	7.25	80.5
19	158	12.80	11.44	12.14	9.33	14.50	6.17	17.15	7.18	78.5
20	162	12.79	11.66	11.93	9.79	14.03	6.52	16.33	7.25	76.5
21	166	12.77	11.95	11.76	10.27	13.61	6.92	15.58	7.41	74.7
22	170	12.77	12.24	11.64	10.76	13.23	7.33	14.86	7.57	72.9
23	174	12.79	12.60	11.56	11.27	12.88	7.81	14.17	7.90	71.3
24	178	12.84	12.97	11.53	11.78	12.60	8.30	13.55	8.25	69.7
25	182	12.87	13.37	11.52	12.31	12.34	8.80	12.94	8.65	68.1
26	187	13.10	13.93	11.53	12.98	12.07	9.45	12.28	9.27	66.3
27	191	13.37	14.31	11.61	13.54	11.91	9.99	11.82	9.78	64.9
28	196	13.61	14.48	11.84	14.24	11.77	10.70	11.33	10.51	63.3
29	201	13.66	14.68	12.17	14.87	11.70	11.42	10.90	11.28	61.7
30	206	13.73	15.05	12.46	15.28	11.68	12.08	10.57	12.07	60.2
31	211	13.83	15.41	12.68	15.70	11.67	12.75	10.30	12.89	58.8
32	216	13.96	15.78	12.91	16.11	11.74	13.45	10.12	13.75	57.4
33	221	14.08	16.14	13.17	16.52	11.96	14.12	10.00	14.65	56.1
34	227	14.24	16.58	13.40	17.02	12.17	14.70	9.98	15.67	54.6
35	232	14.41	16.95	13.61	17.43	12.33	15.20	10.08	16.49	53.4
36	238	14.55	17.38	13.90	17.93	12.50	15.79	10.30	17.52	52.1
37	244	14.70	17.82	14.23	18.43	12.69	16.39	10.63	18.56	50.8
38	250	14.88	18.26	14.59	18.94	12.93	16.98	11.08	19.27	49.6
39	256	14.99	18.70	14.95	19.33	13.16	17.58	11.52	19.99	48.4
40	262	15.10	19.20	15.33	19.70	13.39	18.18	11.95	20.72	47.3
41	269	15.24	19.95	15.70	20.13	13.71	18.90	12.48	21.45	46.1
42	275	15.52	20.59	16.01	20.50	14.07	19.52	12.96	22.02	45.1
43	282	15.69	21.22	16.38	20.93	14.54	20.10	13.51	22.69	44.0
44	289	15.37	21.81	16.75	21.37	14.97	20.62	14.15	23.27	42.9
45	296	16.78	24.28	17.12	21.81	15.36	21.14	14.70	23.77	41.9
46	303	18.11	24.44	17.49	22.24	15.73	21.66	15.26	24.27	40.9
47	311	19.17	24.63	17.90	22.74	16.17	22.26	15.92	24.77	39.9
48	318	19.95	24.78	18.31	23.17	16.55	22.78	16.44	25.16	39.0
49	326	20.73	24.96	18.78	23.66	17.02	23.38	17.02	25.62	38.0
50	334	21.42	25.13	19.26	24.15	17.51	23.98	17.60	26.03	37.1
51	342	22.08	25.30	19.78	24.64	18.01	24.58	18.17	26.44	36.3
52	351	22.79	25.49	20.36	25.19	18.60	25.25	18.75	26.90	35.3
53	359	23.38	25.66	20.91	25.67	19.17	25.85	19.26	27.30	34.5
54	368	24.04	25.84	21.57	26.22	19.86	26.53	19.81	27.75	33.7
55	377	24.70	26.02	22.29	26.76	20.64	27.21	20.24	28.24	32.9
56	386	25.35	26.19	23.17	27.30	21.61	27.88	21.02	29.15	32.1
57	396	26.13	26.37	24.29	27.76	22.83	28.47	22.16	29.89	31.3
58	406	26.84	26.36	25.29	27.79	23.97	28.57	23.29	30.07	30.5
59	415	27.42	26.35	26.03	27.82	24.78	28.65	24.08	30.23	29.9
60	426	28.03	26.34	26.86	27.85	25.71	28.75	24.99	30.42	29.1
61	436	28.53	26.33	27.57	27.88	26.51	28.84	25.80	30.59	28.4
62	447	29.02	26.33	28.31	27.92	27.37	28.94	26.68	30.78	27.7
63	458	29.37	26.47	29.04	27.90	28.19	28.98	27.55	30.89	27.1
64	469	29.83	26.74	29.68	27.85	28.97	28.96	28.38	30.93	26.4

N	E(eV)	Ir (77) Iridium f_1	Ir (77) Iridium f_2	Pt (78) Platinum f_1	Pt (78) Platinum f_2	Au (79) Gold f_1	Au (79) Gold f_2	Hg (80) Mercury f_1	Hg (80) Mercury f_2	λ(A)
65	480	30.35	27.00	30.28	27.80	29.69	28.95	29.16	30.97	25.83
66	492	30.97	27.29	30.83	27.75	30.42	28.94	29.95	31.02	25.20
67	504	31.65	27.57	31.31	27.69	31.10	28.92	30.72	31.07	24.60
68	516	32.40	27.85	31.64	27.64	31.81	28.91	31.51	31.11	24.03
69	529	33.35	28.04	31.73	27.86	32.56	28.84	32.40	31.08	23.44
70	542	34.22	28.00	32.30	28.68	33.18	28.66	33.14	30.88	22.87
71	555	35.05	27.96	33.18	29.51	33.71	28.49	33.78	30.69	22.34
72	569	35.90	27.89	34.56	29.61	34.01	28.27	34.24	30.47	21.79
73	583	36.71	27.72	35.64	29.50	34.19	28.57	34.59	30.63	21.27
74	597	37.43	27.53	36.55	29.33	34.66	29.05	35.14	30.93	20.77
75	612	38.15	27.33	37.45	29.16	35.38	29.56	35.87	31.25	20.26
76	627	38.83	27.13	38.29	29.00	36.30	30.06	36.71	31.56	19.77
77	642	39.50	26.88	39.16	28.77	37.65	30.29	37.77	31.74	19.31
78	658	39.98	26.50	39.93	28.37	38.79	29.89	38.80	31.64	18.84
79	674	40.26	26.14	40.58	27.98	39.67	29.50	39.75	31.54	18.39
80	690	40.64	26.54	41.09	27.70	40.32	29.23	40.70	31.39	17.97
81	707	41.51	27.01	41.58	27.47	40.93	29.01	41.72	31.18	17.54
82	725	42.66	26.56	42.13	27.43	41.60	28.98	42.67	30.69	17.10
83	742	43.41	26.16	42.73	27.40	42.31	28.96	43.41	30.24	16.71
84	760	44.10	25.75	43.50	27.36	43.18	28.93	43.98	29.78	16.31
85	779	44.76	25.33	44.40	27.25	44.20	28.83	44.48	29.38	15.92
86	798	45.35	24.90	45.29	26.76	45.18	28.31	44.97	29.33	15.54
87	818	45.89	24.46	46.01	26.26	45.98	27.79	45.64	29.27	15.16
88	838	46.40	24.04	46.62	25.79	46.67	27.29	46.51	29.22	14.79
89	858	46.88	23.63	47.20	25.32	47.29	26.80	47.45	29.01	14.45
90	879	47.33	23.19	47.73	24.84	47.90	26.32	48.38	28.43	14.10
91	901	47.76	22.76	48.23	24.36	48.45	25.83	49.10	27.85	13.76
92	923	48.18	22.34	48.70	23.90	48.97	25.36	49.74	27.29	13.43
93	945	48.56	21.90	49.12	23.43	49.46	24.88	50.31	26.75	13.12
94	968	48.91	21.45	49.52	22.94	49.92	24.40	50.85	26.21	12.81
95	992	49.24	20.99	49.90	22.46	50.36	23.91	51.38	25.68	12.50
96	1016	49.55	20.54	50.27	21.99	50.79	23.43	51.88	25.15	12.20
97	1041	49.85	20.07	50.61	21.48	51.22	22.90	52.38	24.54	11.91
98	1067	50.06	19.58	50.89	20.96	51.55	22.36	52.74	23.93	11.62
99	1093	50.26	19.12	51.13	20.47	51.85	21.84	53.07	23.36	11.34
100	1119	50.42	18.68	51.34	20.01	52.11	21.34	53.36	22.81	11.08
101	1147	50.56	18.23	51.53	19.53	52.36	20.83	53.63	22.25	10.81
102	1175	50.67	17.80	51.67	19.07	52.56	20.34	53.92	21.72	10.55
103	1204	50.75	17.38	51.80	18.62	52.73	19.86	54.08	21.19	10.30
104	1233	50.81	16.97	51.91	18.19	52.89	19.41	54.27	20.69	10.06
105	1263	50.84	16.57	52.00	17.76	53.02	18.95	54.43	20.19	9.82
106	1294	50.85	16.15	52.05	17.31	53.12	18.49	54.55	19.70	9.58
107	1326	50.82	15.74	52.07	16.88	53.20	18.03	54.66	19.22	9.35
108	1358	50.75	15.36	52.07	16.47	53.25	17.60	54.73	18.77	9.13
109	1392	50.65	14.97	52.01	16.05	53.25	17.16	54.78	18.30	8.91
110	1426	50.50	14.59	51.93	15.65	53.23	16.74	54.81	17.86	8.69
111	1460	50.32	14.24	51.83	15.27	53.19	16.34	54.82	17.44	8.49
112	1496	50.10	13.88	51.68	14.89	53.12	15.94	54.81	17.01	8.29
113	1533	49.82	13.52	51.48	14.50	53.00	15.53	54.76	16.57	8.09
114	1570	49.48	13.18	51.24	14.13	52.84	15.13	54.67	16.14	7.90
115	1609	49.06	12.83	50.95	13.76	52.64	14.74	54.55	15.72	7.71
116	1648	48.58	12.50	50.58	13.41	52.38	14.37	54.36	15.32	7.52
117	1688	47.97	12.19	50.14	13.07	52.07	14.00	54.14	14.92	7.34
118	1730	47.27	11.87	49.63	12.72	51.70	13.64	53.88	14.53	7.17
119	1772	46.41	11.55	49.01	12.38	51.26	13.27	53.56	14.14	7.00
120	1815	45.24	11.24	48.22	12.04	50.69	12.91	53.14	13.75	6.83
121	1860	43.72	10.93	47.23	11.71	50.00	12.56	52.65	13.37	6.67
122	1905	41.12	10.63	46.01	11.39	49.18	12.22	52.07	13.00	6.51
123	1952	32.63	10.34	43.73	11.08	47.86	11.88	51.19	12.64	6.35
124	2000	23.97	10.05	41.41	10.77	46.52	11.56	50.30	12.29	6.20
	$\frac{E_U(E)}{f_2}$	218.8		215.6		213.5		209.7		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	192.2		195.1		197.0		200.6		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Tl (81)		Pb (82)		Bi (83)		Po (84)		λ(A)
		f_1	f_2	f_1	f_2	f_1	f_2	f_1	f_2	
0	100	21.24	11.20	23.57	11.09	25.33	18.55	24.73	24.84	124.0
1	102	21.19	10.81	23.51	10.64	25.54	17.94	25.18	23.96	121.5
2	104	21.13	10.44	23.46	10.25	25.73	17.35	25.56	23.12	119.2
3	107	21.02	9.93	23.38	9.70	26.03	16.50	26.06	21.93	115.9
4	110	20.87	9.45	23.32	9.20	26.32	15.70	26.48	20.81	112.7
5	112	20.77	9.15	23.26	8.88	26.49	14.99	26.67	20.15	110.7
6	115	20.58	8.73	23.19	8.40	26.58	14.01	26.94	19.24	107.8
7	118	20.35	8.33	23.09	7.87	26.51	13.18	27.23	18.35	105.1
8	121	20.09	7.95	22.92	7.36	26.40	12.44	27.56	17.52	102.5
9	124	19.75	7.67	22.71	6.89	26.27	11.80	27.75	16.47	100.0
10	127	19.44	7.48	22.43	6.41	26.15	11.21	27.83	15.47	97.6
11	130	19.16	7.29	22.09	5.96	26.03	10.67	27.75	14.61	95.4
12	133	18.81	7.14	21.69	5.65	25.92	10.12	27.62	13.84	93.2
13	136	18.55	7.05	21.26	5.36	25.79	9.56	27.49	13.17	91.2
14	140	18.19	6.95	20.68	5.08	25.54	8.78	27.31	12.36	88.6
15	143	17.93	6.87	20.24	5.02	25.29	8.24	27.18	11.80	86.7
16	147	17.55	6.82	19.77	4.94	24.90	7.53	27.02	11.04	84.3
17	150	17.27	6.80	19.43	4.90	24.49	7.01	26.90	10.45	82.7
18	154	16.92	6.78	19.00	4.86	23.87	6.55	26.60	9.65	80.5
19	158	16.53	6.81	18.56	4.82	23.26	6.13	26.24	8.93	78.5
20	162	16.13	6.85	18.13	4.84	22.58	5.88	25.78	8.19	76.5
21	166	15.73	6.97	17.67	4.86	21.99	5.78	25.20	7.55	74.7
22	170	15.33	7.10	17.21	4.94	21.45	5.68	24.57	7.09	72.9
23	174	14.93	7.31	16.77	5.05	20.96	5.63	23.90	6.66	71.3
24	178	14.56	7.54	16.32	5.19	20.47	5.58	23.19	6.46	69.7
25	182	14.18	7.76	15.88	5.38	19.97	5.56	22.60	6.35	68.1
26	187	13.70	8.18	15.36	5.64	19.36	5.57	21.93	6.24	66.3
27	191	13.38	8.54	14.95	5.87	18.85	5.61	21.41	6.18	64.9
28	196	13.01	9.00	14.42	6.18	18.23	5.74	20.78	6.11	63.3
29	201	12.64	9.40	13.90	6.56	17.61	5.90	20.15	6.11	61.7
30	206	12.21	10.00	13.38	6.95	17.01	6.15	19.51	6.12	60.2
31	211	11.86	10.68	12.84	7.38	16.43	6.42	18.85	6.22	58.8
32	216	11.62	11.38	12.21	7.87	15.87	6.73	18.21	6.35	57.4
33	221	11.42	12.10	11.57	8.54	15.30	7.06	17.59	6.56	56.1
34	227	11.24	13.01	10.80	9.58	14.62	7.55	16.86	6.86	54.6
35	232	11.18	13.80	10.41	10.77	14.03	7.97	16.27	7.16	53.4
36	238	11.21	14.72	10.22	12.16	13.29	8.52	15.57	7.54	52.1
37	244	11.35	15.60	10.43	13.55	12.40	9.27	14.85	8.00	50.8
38	250	11.54	16.50	10.77	14.43	11.54	10.17	14.09	8.50	49.6
39	256	11.85	17.43	11.11	15.31	10.94	11.64	13.34	9.05	48.4
40	262	12.28	18.17	11.41	16.15	10.65	13.18	12.55	9.66	47.3
41	269	12.68	18.92	11.80	17.02	10.95	14.88	11.58	10.69	46.1
42	275	13.08	19.57	12.10	17.74	11.28	15.90	10.76	11.92	45.1
43	282	13.58	20.30	12.53	18.60	11.64	16.99	10.34	13.79	44.0
44	289	14.09	20.90	12.99	19.30	12.08	18.03	10.31	15.49	42.9
45	296	14.60	21.50	13.42	20.03	12.50	18.92	10.72	16.98	41.9
46	303	15.12	22.10	13.94	20.82	12.95	19.80	11.12	18.10	40.9
47	311	15.72	22.63	14.61	21.50	13.54	20.80	11.59	19.30	39.9
48	318	16.22	23.09	15.15	22.01	14.04	21.49	12.08	20.26	39.0
49	326	16.80	23.60	15.70	22.57	14.64	22.40	12.57	21.28	38.0
50	334	17.35	24.02	16.22	23.12	15.28	23.22	13.14	22.31	37.1
51	342	17.85	24.44	16.74	23.68	15.99	23.88	13.76	23.16	36.3
52	351	18.36	24.92	17.38	24.30	16.69	24.51	14.34	24.16	35.3
53	359	18.81	25.36	17.92	24.74	17.30	25.07	15.03	25.05	34.5
54	368	19.31	25.85	18.51	25.29	17.98	25.70	15.83	25.82	33.7
55	377	19.79	26.34	19.15	25.82	18.66	26.32	16.57	26.45	32.9
56	386	20.03	26.83	19.79	26.27	19.33	26.83	17.26	27.08	32.1
57	396	20.24	28.70	20.46	26.72	20.05	27.45	17.97	27.79	31.3
58	406	21.95	28.96	21.09	27.08	20.88	28.01	18.74	28.49	30.5
59	415	22.89	29.19	21.52 N	27.43	21.59	28.45	19.41	29.01	29.9
60	426	23.92	29.47	21.90	27.92	22.40	28.89	20.20	29.67	29.1
61	436	24.76	29.71	22.26	28.58	23.09	29.24	20.90	30.26	28.4
62	447	25.66	29.98	22.98	29.95	23.75	29.83	21.67	30.78	27.7
63	458	26.55	30.20	24.29	30.73	24.58	30.40	22.16	31.22	27.1
64	469	27.38	30.36	25.51	30.99	25.43	30.86	21.61	31.60	26.4

N	E(eV)	Tl (81) Thallium f_1	Tl (81) Thallium f_2	Pb (82) Lead f_1	Pb (82) Lead f_2	Bi (83) Bismuth f_1	Bi (83) Bismuth f_2	Po (84) Polonium f_1	Po (84) Polonium f_2	λ(A)
65	480	28.19	30.52	26.52	31.24	26.25	31.30	22.78	35.25	25.83
66	492	29.03	30.69	27.53	31.51	27.18	31.79	26.01	35.25	25.20
67	504	29.86	30.86	28.51	31.78	28.15	32.27	27.57	35.25	24.60
68	516	30.73	31.02	29.55	32.05	29.23	32.74	28.99	35.25	24.03
69	529	31.74	31.11	30.75	32.21	30.58	33.08	30.37	35.20	23.44
70	542	32.63	30.99	31.81	32.11	31.76	33.02	31.58	35.05	22.87
71	555	33.47	30.88	32.77	32.02	32.84	32.96	32.67	34.90	22.34
72	569	34.27	30.74	33.73	31.92	33.92	32.89	33.76	34.76	21.79
73	583	34.99	30.55	34.61	31.74	34.92	32.74	34.79	34.57	21.27
74	597	35.59	30.34	35.39	31.54	35.80	32.56	35.70	34.35	20.77
75	612	36.11	30.12	36.14	31.33	36.67	32.36	36.61	34.13	20.26
76	627	36.49	29.91	36.81	31.12	37.49	32.18	37.47	33.91	19.77
77	642	36.49	30.03	37.40	30.90	38.27	31.96	38.28	33.66	19.31
78	658	36.94	30.86	37.71	30.60	38.97	31.68	39.02	33.33	18.84
79	674	37.80	31.70	37.73	30.32	39.59	31.40	39.64	33.01	18.39
80	690	39.18	31.96	37.59	31.51	40.04	31.12	40.01	32.78	17.97
81	707	40.58	31.91	39.04	33.26	40.24	30.91	40.29	32.65	17.54
82	725	41.73	31.44	41.04	32.83	40.58	31.44	40.67	33.19	17.10
83	742	42.63	31.02	42.30	32.43	41.18	31.93	41.40	33.70	16.71
84	760	43.30	30.58	43.32	32.03	42.22	32.44	42.52	34.23	16.31
85	779	43.88	30.21	44.31	31.61	43.55	32.82	43.94	34.63	15.92
86	798	44.40	30.22	45.16	31.14	44.93	32.39	45.37	34.16	15.54
87	818	45.14	30.22	45.93	30.66	46.01	31.95	46.51	33.68	15.16
88	838	46.09	30.23	46.52	30.20	46.93	31.52	47.50	33.22	14.79
89	858	47.10	30.08	47.00	29.86	47.77	31.09	48.40	32.76	14.45
90	879	48.11	29.55	47.56	29.79	48.55	30.59	49.19	32.23	14.10
91	901	48.90	29.02	48.31	29.71	49.21	30.08	49.91	31.69	13.76
92	923	49.61	28.51	49.21	29.64	49.74	29.60	50.49	31.18	13.43
93	945	50.24	28.06	50.16	29.25	50.21	29.37	50.98	30.95	13.12
94	968	50.87	27.62	51.01	28.70	50.79	29.25	51.62	30.83	12.81
95	992	51.55	27.18	51.76	28.15	51.61	29.12	52.41	30.71	12.50
96	1016	52.23	26.72	52.47	27.61	52.52	28.91	53.47	30.51	12.20
97	1041	52.88	26.06	53.14	26.97	53.44	28.26	54.44	29.82	11.91
98	1067	53.39	25.40	53.66	26.33	54.12	27.60	55.21	29.12	11.62
99	1093	53.84	24.78	54.12	25.72	54.70	26.98	55.85	28.45	11.34
100	1119	54.23	24.19	54.54	25.14	55.22	26.38	56.40	27.81	11.08
101	1147	54.60	23.58	54.95	24.54	55.71	25.77	56.93	27.16	10.81
102	1175	54.90	23.00	55.35	23.97	56.12	25.19	57.39	26.53	10.55
103	1204	55.18	22.43	55.62	23.41	56.52	24.61	57.81	25.92	10.30
104	1233	55.43	21.88	55.91	22.87	56.89	24.06	58.21	25.33	10.06
105	1263	55.64	21.35	56.17	22.34	57.21	23.52	58.57	24.75	9.82
106	1294	55.82	20.82	56.39	21.83	57.50	22.98	58.89	24.17	9.58
107	1326	55.98	20.30	56.60	21.32	57.77	22.46	59.19	23.61	9.35
108	1358	56.11	19.81	56.79	20.84	58.01	21.95	59.45	23.07	9.13
109	1392	56.21	19.31	56.95	20.35	58.23	21.45	59.69	22.53	8.91
110	1426	56.29	18.83	57.10	19.89	58.43	20.96	59.92	22.01	8.69
111	1460	56.36	18.38	57.23	19.45	58.60	20.50	60.13	21.52	8.49
112	1496	56.40	17.92	57.35	18.98	58.78	20.02	60.35	21.00	8.29
113	1533	56.39	17.46	57.43	18.49	58.92	19.50	60.5[illegible]	20.47	8.09
114	1570	56.36	17.01	57.47	18.03	59.02	19.01	60.64	19.95	7.90
115	1609	56.30	16.57	57.48	17.56	59.10	18.52	60.73	19.44	7.71
116	1648	56.20	16.15	57.44	17.11	59.12	18.05	60.79	18.95	7.52
117	1688	56.06	15.74	57.38	16.68	59.12	17.60	60.83	18.47	7.34
118	1730	55.89	15.33	57.29	16.24	59.09	17.14	60.86	18.00	7.17
119	1772	55.67	14.91	57.16	15.81	59.05	16.69	60.85	17.52	7.00
120	1815	55.38	14.50	56.97	15.38	58.94	16.23	60.80	17.04	6.83
121	1860	55.02	14.10	56.72	14.96	58.78	15.78	60.71	16.57	6.67
122	1905	54.61	13.7[illegible]	56.42	14.56	58.57	15.35	60.53	16.13	6.51
123	1952	54.01	13.33	55.99	14.16	58.27	14.93	60.33	15.68	6.35
124	2000	53.39	12.96	55.54	13.77	57.95	14.52	60.12	15.25	6.20
	$\frac{E\mu(E)}{f_2}$	205.8		203.0		201.2		200.3		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	204.4		207.2		209.0		210.0		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	At (85) f_1	At (85) f_2	Rn (86) f_1	Rn (86) f_2	Fr (87) f_1	Fr (87) f_2	Ra (88) f_1	Ra (88) f_2	λ(A)
0	100	19.95	30.38	15.67	35.48	16.18	34.80	12.43	35.66	124.0
1	102	20.97	29.72	17.58	34.64	17.44	34.17	14.03	35.80	121.5
2	104	22.01	28.99	18.95	33.83	18.56	33.57	15.73	35.70	119.2
3	107	23.33	27.36	20.77	32.68	20.14	32.70	18.11	35.01	115.9
4	110	24.18	25.88	22.31	31.60	21.53	31.88	20.14	34.23	112.7
5	112	24.57	25.02	23.25	30.92	22.43	31.35	21.42	33.73	110.7
6	115	25.11	23.82	24.69	29.91	23.86	30.60	23.23	32.71	107.8
7	118	25.58	22.66	25.94	28.44	25.28	29.75	24.81	31.59	105.1
8	121	25.93	21.58	26.86	27.07	26.62	28.32	26.27	30.47	102.5
9	124	26.20	20.64	27.51	25.81	27.46	27.00	27.41	29.01	100.0
10	127	26.47	19.77	28.05	24.63	28.13	25.76	28.33	27.65	97.6
11	130	26.75	18.91	28.50	23.53	28.70	24.61	29.07	26.35	95.4
12	133	27.05	18.10	28.90	22.50	29.17	23.54	29.62	25.13	93.2
13	136	27.20	17.04	29.19	21.54	29.45	22.53	30.04	24.00	91.2
14	140	27.23	15.79	29.56	20.35	29.84	21.29	30.49	22.60	88.6
15	143	27.14	14.97	29.85	19.42	30.10	20.42	30.76	21.60	86.7
16	147	26.95	14.03	30.00	18.17	30.41	19.23	30.97	20.36	84.3
17	150	26.79	13.40	30.06	17.31	30.58	18.36	31.09	19.50	82.7
18	154	26.62	12.63	30.02	16.24	30.58	17.27	31.14	18.43	80.5
19	158	26.46	11.90	29.92	15.27	30.55	16.27	31.13	17.46	78.5
20	162	26.29	11.19	29.77	14.38	30.46	15.36	31.09	16.62	76.5
21	166	26.04	10.37	29.58	13.56	30.34	14.52	31.04	15.83	74.7
22	170	25.74	9.63	29.37	12.80	30.20	13.74	30.97	15.11	72.9
23	174	25.36	8.94	29.12	12.11	30.01	13.02	30.92	14.43	71.3
24	178	24.82	8.22	28.85	11.46	29.78	12.35	30.85	13.72	69.7
25	182	24.24	7.68	28.57	10.86	29.56	11.73	30.74	13.03	68.1
26	187	23.48	7.13	28.21	10.18	29.24	11.02	30.53	12.24	66.3
27	191	22.77	6.75	27.91	9.62	29.00	10.49	30.31	11.66	64.9
28	196	21.99	6.62	27.45	8.94	28.69	9.84	30.05	11.00	63.3
29	201	21.30	6.49	26.93	8.33	28.34	9.10	29.79	10.34	61.7
30	206	20.68	6.41	26.35	7.77	27.85	8.43	29.52	9.72	60.2
31	211	20.05	6.34	25.67	7.26	27.29	7.83	29.15	8.99	58.8
32	216	19.44	6.30	24.89	6.96	26.59	7.28	28.61	8.34	57.4
33	221	18.83	6.31	24.17	6.89	25.79	6.94	27.98	7.84	56.1
34	227	18.06	6.37	23.48	6.79	24.99	6.78	27.27	7.45	54.6
35	232	17.44	6.50	22.92	6.72	24.36	6.65	26.67	7.14	53.4
36	238	16.70	6.69	22.24	6.64	23.61	6.50	25.94	6.93	52.1
37	244	15.99	6.98	21.52	6.68	22.82	6.54	25.28	6.81	50.8
38	250	15.28	7.30	20.88	6.78	22.15	6.65	24.66	6.69	49.6
39	256	14.58	7.67	20.22	6.88	21.52	6.76	24.03	6.58	48.4
40	262	13.90	8.08	19.52	6.98	20.91	6.87	23.38	6.48	47.3
41	269	13.10	8.64	18.73	7.31	20.11	7.00	22.55	6.59	46.1
42	275	12.44	9.15	18.16	7.63	19.47	7.30	21.91	6.71	45.1
43	282	11.56	9.78	17.43	8.01	18.70	7.66	21.21	6.86	44.0
44	289	10.58	10.76	16.80	8.40	18.00	8.04	20.47	7.03	42.9
45	296	9.67	12.03	16.17	8.80	17.38	8.51	19.67	7.36	41.9
46	303	9.12	13.80	15.50	9.21	16.79	9.00	18.93	7.70	40.9
47	311	8.98	15.72	14.67	9.68	16 12	9.58	18.17	8.12	39.9
48	318	9.44	17.24	13.64	10.24	15.53	10.10	17.48	8.57	39.0
49	326	9.94	18.46	12.66	11.40	14.78	10.72	16.67	9.11	38.0
50	334	10.41	19.63	11.86	12.66	13.93	11.35	15.80	9.66	37.1
51	342	10.90	20.71	11.20	14.02	12.92	12.26	14.77	10.43	36.3
52	351	11.45	21.80	10.64	15.69	12.01	13.82	13.82	11.72	35.3
53	359	12.01	22.79	10.31	17.29	11.40	15.34	13.12	12.98	34.5
54	368	12.69	23.72	10.12	19.24	10.93	17.19	12.47	14.52	33.7
55	377	13.33	24.67	10.27	21.36	10.79	19.22	12.05	16.19	32.9
56	386	14.06	25.60	11.11	23.65	11.25	21.42	11.95	18.01	32.1
57	396	14.88	26.69	12.65	25.98	12.30	23.91	12.14	20.47	31.3
58	406	15.97	27.22	14.36	26.65	13.75	24.82	13.10	21.66	30.5
59	415	16.71	27.70	15.34	27.25	14.57	25.64	13.58	22.76	29.9
60	426	17.55	28.27	16.44	27.99	15.50	26.66	14.17	24.15	29.1
61	436	18.28	28.80	17.37	28.67	16.33	27.60	14.75	25.45	28.4
62	447	19.07	29.37	18.39	29.41	17.31	28.65	15.58	26.93	27.7
63	458	19.85	29.90	19.41	29.99	18.41	29.47	16.65	28.10	27.1
64	469	20.61	30.39	20.35	30.42	19.41	30.07	17.65	28.97	26.4

N	E(eV)	At (85) Astatine f_1	At (85) Astatine f_2	Rn (86) Radon f_1	Rn (86) Radon f_2	Fr (87) Francium f_1	Fr (87) Francium f_2	Ra (88) Radium f_1	Ra (88) Radium f_2	λ(A)
65	480	21.35	30.88	21.20	30.85	20.31	30.66	18.54	29.84	25.83
66	492	22.15	31.40	22.03	31.32	21.25	31.31	19.50	30.81	25.20
67	504	22.95	31.93	22.81	31.78	22.20	31.96	20.54	31.77	24.60
68	516	23.75	32.45	23.54	32.24	23.22	32.61	21.73	32.75	24.03
69	529	24.62	33.02	24.24	32.79	24.49	33.11	23.31	33.52	23.44
70	542	25.55	33.61	24.98	33.48	25.49	33.18	24.59	33.67	22.87
71	555	26.56	34.20	25.74	34.16	26.29	33.26	25.69	33.82	22.34
72	569	27.81	34.83	26.81	35.31	26.66	33.32	26.47	33.94	21.79
73	583	29.19	35.10	28.28	35.92	26.84	34.22	27.08	34.46	21.27
74	597	30.39	35.22	29.60	36.31	27.52	35.44	27.87	35.13	20.77
75	612	31.59	35.35	30.96	36.72	28.63	36.76	28.84	35.85	20.26
76	627	32.78	35.47	32.35	37.13	30.12	38.09	29.90	36.56	19.77
77	642	34.07	35.47	33.99	37.30	32.46	38.92	31.11	37.21	19.31
78	658	35.25	35.21	35.43	36.96	34.51	38.55	32.45	37.76	18.84
79	674	36.33	34.96	36.63	36.63	36.10	38.20	33.81	38.30	18.39
80	690	37.30	34.68	37.63	36.43	37.38	37.97	35.32	38.74	17.97
81	707	38.26	34.37	38.72	36.22	38.70	37.73	37.16	39.08	17.54
82	725	39.12	33.92	39.71	35.78	39.97	37.30	38.93	38.65	17.10
83	742	39.79	33.50	40.51	35.39	41.03	36.91	40.31	38.27	16.71
84	760	40.20	33.08	40.98	34.98	42.02	36.51	41.53	37.87	16.31
85	779	40.45	32.80	41.26	34.73	42.99	36.08	42.77	37.45	15.92
86	798	40.71	33.33	41.59	35.43	43.83	35.57	43.82	36.93	15.54
87	818	41.46	33.89	42.48	36.15	44.53	35.05	44.80	36.41	15.16
88	838	42.71	34.44	44.04	36.88	44.87	34.55	45.67	35.91	14.79
89	858	44.13	34.66	45.83	37.12	45.09	34.39	46.46	35.41	14.45
90	879	45.66	34.10	47.63	36.35	45.43	34.93	47.16	34.85	14.10
91	901	46.74	33.54	48.85	35.59	46.37	35.50	47.66	34.30	13.76
92	923	47.72	33.00	49.86	34.85	47.77	36.05	47.83	33.76	13.43
93	945	48.59	32.44	50.72	34.21	49.31	35.81	47.89	34.00	13.12
94	968	49.38	31.86	51.53	33.61	50.65	35.20	48.34	34.59	12.81
95	992	50.11	31.27	52.30	33.00	51.71	34.59	49.47	35.20	12.50
96	1016	50.78	30.71	53.01	32.41	52.65	34.00	50.89	35.57	12.20
97	1041	51.39	30.11	53.66	31.77	53.50	33.33	52.36	34.87	11.91
98	1067	51.90	29.62	54.23	31.27	54.18	32.82	53.35	34.40	11.62
99	1093	52.42	29.15	54.80	30.79	54.88	32.33	54.26	33.94	11.34
100	1119	52.93	28.70	55.37	30.32	55.56	31.86	55.11	33.50	11.08
101	1147	53.46	28.23	55.95	29.84	56.25	31.38	55.96	33.04	10.81
102	1175	53.99	27.78	56.55	29.38	56.98	30.91	56.77	32.60	10.55
103	1204	54.46	27.33	57.09	28.93	57.59	30.44	57.59	32.16	10.30
104	1233	54.95	26.90	57.67	28.48	58.27	29.99	58.42	31.74	10.06
105	1263	55.49	26.42	58.30	27.99	59.02	29.47	59.34	31.22	9.82
106	1294	55.95	25.84	58.85	27.37	59.66	28.79	60.12	30.46	9.58
107	1326	56.37	25.27	59.34	26.75	60.23	28.12	60.81	29.73	9.35
108	1358	56.73	24.72	59.77	26.17	60.72	27.48	61.41	29.02	9.13
109	1392	57.05	24.17	60.15	25.58	61.17	26.83	61.94	28.31	8.91
110	1426	57.35	23.64	60.51	25.01	61.58	26.21	62.41	27.63	8.69
111	1460	57.61	23.13	60.84	24.47	61.96	25.62	62.83	26.99	8.49
112	1496	57.88	22.60	61.19	23.91	62.33	25.02	63.24	26.33	8.29
113	1533	58.09	22.04	61.47	23.31	62.65	24.39	63.59	25.68	8.09
114	1570	58.26	21.50	61.71	22.75	62.92	23.79	63.92	25.05	7.90
115	1609	58.40	20.96	61.93	22.18	63.18	23.19	64.22	24.42	7.71
116	1648	58.49	20.45	62.10	21.63	63.38	22.62	64.47	23.83	7.52
117	1688	58.56	19.95	62.25	21.11	63.57	22.06	64.71	23.25	7.34
118	1730	58.62	19.45	62.39	20.58	63.73	21.50	64.93	22.66	7.17
119	1772	58.63	18.94	62.50	20.05	63.87	20.95	65.12	22.08	7.00
120	1815	58.59	18.44	62.55	19.52	63.96	20.40	65.26	21.51	6.83
121	1860	58.51	17.94	62.57	19.00	64.03	19.86	65.37	20.94	6.67
122	1905	58.39	17.47	62.56	18.51	64.07	19.34	65.46	20.40	6.51
123	1952	58.18	17.00	62.49	18.01	64.05	18.83	65.49	19.86	6.35
124	2000	57.96	16.54	62.42	17.54	64.03	18.33	65.52	19.34	6.20
	$\frac{E\mu(E)}{f_2}$	200.3		189.4		188.6		186.1		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	210.0		222.0		223.0		226.0		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Ac (89) f_1	Ac (89) f_2	Th (90) f_1	Th (90) f_2	Pa (91) f_1	Pa (91) f_2	U (92) f_1	U (92) f_2	λ(A)
0	100	6.27	35.58	-21.01	71.91	-18.92	22.68	-6.11	25.08	124.0
1	102	8.77	36.19	13.12	81.59	-23.87	33.00	-11.25	12.35	121.5
2	104	10.97	35.82	27.52	56.16	-20.01	47.67	-15.63	21.05	119.2
3	107	13.82	35.00	29.80	43.26	-0.73	78.19	-19.33	39.89	115.9
4	110	15.96	34.21	29.25	38.76	24.25	61.36	-11.68	53.79	112.7
5	112	17.18	33.70	29.66	36.24	30.07	52.40	0.89	63.45	110.7
6	115	18.87	32.97	30.05	33.43	34.18	41.56	19.44	61.75	107.8
7	118	20.37	32.27	30.97	30.91	33.55	33.85	33.07	50.47	105.1
8	121	21.79	31.60	31.33	28.78	32.08	31.40	35.14	39.39	102.5
9	124	23.07	30.97	31.82	27.12	32.15	29.18	34.47	31.84	100.0
10	127	24.46	30.36	32.31	25.50	32.29	27.16	32.55	29.62	97.6
11	130	25.86	29.52	32.70	23.82	32.47	25.33	32.20	27.59	95.4
12	133	27.07	28.36	32.78	22.29	32.60	23.66	31.97	26.09	93.2
13	136	27.88	27.27	33.04	20.89	32.61	22.13	32.35	24.77	91.2
14	140	28.82	25.91	33.07	19.20	32.58	20.29	32.75	22.54	88.6
15	143	29.42	24.96	33.00	18.05	32.51	19.05	32.76	21.05	86.7
16	147	30.04	23.78	32.81	16.66	32.33	17.54	32.73	19.35	84.3
17	150	30.44	22.95	32.70	15.71	32.18	16.51	32.82	18.19	82.7
18	154	30.91	21.91	32.42	14.55	31.87	15.26	32.64	16.33	80.5
19	158	31.32	20.94	32.14	13.51	31.53	14.13	32.12	14.78	78.5
20	162	31.75	20.04	31.80	12.56	31.15	13.11	31.51	13.69	76.5
21	166	32.07	18.95	31.42	11.70	30.74	12.19	31.01	12.70	74.7
22	170	32.29	17.93	31.02	10.91	30.31	11.35	30.49	11.80	72.9
23	174	32.36	16.99	30.56	10.20	29.84	10.59	29.99	10.99	71.3
24	178	32.35	16.12	30.15	9.55	29.35	9.89	29.47	10.24	69.7
25	182	32.33	15.31	29.63	8.95	28.86	9.26	28.89	9.57	68.1
26	187	32.21	14.38	29.02	8.27	28.16	8.54	28.17	8.80	66.3
27	191	32.07	13.69	28.47	7.78	27.57	8.01	27.55	8.25	64.9
28	196	31.88	12.90	27.69	7.21	26.71	7.42	26.66	7.62	63.3
29	201	31.64	12.17	26.71	6.82	25.71	7.00	25.61	7.18	61.7
30	206	31.37	11.50	25.86	6.91	24.80	7.09	24.65	7.27	60.2
31	211	31.09	10.87	25.20	7.00	24.13	7.18	23.93	7.36	58.8
32	216	30.78	10.30	24.67	7.08	23.57	7.27	23.34	7.45	57.4
33	221	30.46	9.74	24.20	7.17	23.05	7.36	22.82	7.54	56.1
34	227	30.00	9.09	23.67	7.27	22.50	7.46	22.23	7.65	54.6
35	232	29.58	8.59	23.25	7.36	22.06	7.55	21.78	7.74	53.4
36	238	29.03	8.05	22.74	7.46	21.53	7.65	21.23	7.85	52.1
37	244	28.40	7.54	22.20	7.55	20.98	7.75	20.65	7.95	50.8
38	250	27.62	7.09	21.58	7.65	20.32	7.85	19.98	8.05	49.6
39	256	26.86	6.95	20.99	8.06	19.71	8.27	19.36	8.48	48.4
40	262	26.15	6.89	20.49	8.48	19.17	8.71	18.82	8.93	47.3
41	269	25.42	6.82	20.00	8.99	18.69	9.23	18.29	9.46	46.1
42	275	24.77	6.76	19.63	9.44	18.30	9.69	17.90	9.93	45.1
43	282	24.00	6.84	19.26	9.97	17.90	10.24	17.51	10.49	44.0
44	289	23.28	6.93	18.91	10.53	17.54	10.80	17.14	11.08	42.9
45	296	22.40	7.04	18.58	11.09	17.22	11.39	16.81	11.68	41.9
46	303	21.62	7.38	18.31	11.69	16.94	11.99	16.53	12.30	40.9
47	311	20.87 N	7.77	18.04	12.40	16.58	12.72	16.23	13.04	39.9
48	318	20.17	8.12	17.86	13.04	16.33	13.38	16.04	13.72	39.0
49	326	19.35	8.53	17.70	13.79	16.20	14.15	15.83	14.51	38.0
50	334	18.48	8.95	17.61	14.56	16.12	14.95	15.71	15.33	37.1
51	342	17.49	9.78	17.61	15.36	16.07	15.77	15.69	16.17	36.3
52	351	16.64	10.84	17.78	16.25	16.26	16.68	15.86	17.10	35.3
53	359	15.99	11.86	17.94	16.79	16.39 N	17.23	16.00	17.66	34.5
54	368	15.37	13.10	18.08	17.39	16.49	17.85	16.14	18.30	33.7
55	377	14.88	14.42	18.17	18.00	16.55	18.47	16.20	18.94	32.9
56	386	14.52	15.84	18.24	18.62	16.54	19.11	16.24	19.59	32.1
57	396	14.28	17.84	18.31	19.31	16.55	19.82	16.26	20.32	31.3
58	406	14.67	19.11	18.41	20.00	16.45	20.66	16.28	21.15	30.5
59	415	14.82	20.29	18.47	20.63	16.46	21.51	16.34	21.96	29.9
60	426	15.06	21.81	18.55	21.41	16.55	22.58	16.47	22.96	29.1
61	436	15.39	23.24	18.59	22.12	16.69	23.56	16.63	23.90	28.4
62	447	15.99	24.89	18.56	22.91	16.94	24.67	16.87	24.94	27.7
63	458	16.88	26.26	18.42	23.97	17.25	25.80	17.17	26.00	27.1
64	469	17.73	27.33	18.50	25.30	17.64	26.96	17.53	27.08	26.4

N	E(eV)	Ac (89) Actinium f_1	Ac (89) Actinium f_2	Th (90) Thorium f_1	Th (90) Thorium f_2	Pa (91) Protactinium f_1	Pa (91) Protactinium f_2	U (92) Uranium f_1	U (92) Uranium f_2	λ(A)
65	480	18.50	28.43	18.75	26.68	18.09	28.13	17.95	28.18	25.83
66	492	19.38	29.64	19.27	28.22	18.75	29.44	18.51	29.40	25.20
67	504	20.39	30.88	20.06	29.82	19.54	30.78	19.17	30.64	24.60
68	516	21.65	32.14	21.23	31.46	20.60	32.15	19.95	31.90	24.03
69	529	23.44	33.16	23.16	32.80	22.16	33.35	21.08	33.20	23.44
70	542	24.93	33.39	24.76	33.08	23.55	33.89	22.42	34.34	22.87
71	555	26.27	33.63	26.16	33.36	24.87	34.43	23.88	35.48	22.34
72	569	27.47	33.85	27.42	33.64	26.22	35.01	25.66	35.94	21.79
73	583	28.55	33.92	28.55	33.74	27.59	35.29	27.11	36.14	21.27
74	597	29.40	33.94	29.50	33.79	28.76	35.46	28.39	36.27	20.77
75	612	30.13	33.97	30.38	33.83	29.92	35.65	29.61	36.41	20.26
76	627	30.64	33.99	31.10	33.87	31.02	35.82	30.74	36.55	19.77
77	642	30.56	34.42	31.63	33.84	32.18	35.88	31.85	36.61	19.31
78	658	31.04	35.91	30.35	33.63	33.14	35.67	32.90	36.49	18.84
79	674	32.01	37.42	26.84 N	33.42	33.93	35.46	33.73	36.37	18.39
80	690	33.69	38.60	33.19	38.89	34.39	35.36	34.44	36.31	17.97
81	707	35.97	39.60	35.59	38.80	34.52	35.39	35.08	36.27	17.54
82	725	38.20	39.21	37.32	38.70	34.86	36.40	35.58	36.23	17.10
83	742	39.82	38.86	38.80	38.61	35.55	37.36	32.70 N	38.41	16.71
84	760	41.21	38.51	40.20	38.52	36.81	38.37	35.54	38.78	16.31
85	779	42.60	38.12	41.65	38.38	38.44	39.29	37.82	39.16	15.92
86	798	43.79	37.63	43.00	38.01	40.22	39.29	39.24	39.54	15.54
87	818	44.89	37.13	44.20	37.64	41.72	39.28	40.61	39.93	15.16
88	838	45.85	36.66	45.33	37.28	43.24	39.27	42.15	40.31	14.79
89	858	46.71	36.18	46.39	36.88	44.69	39.10	43.88	40.40	14.45
90	879	47.51	35.65	47.37	36.37	46.16	38.58	45.48	39.89	14.10
91	901	48.12	35.12	48.26	35.86	47.35	38.05	46.85	39.36	13.76
92	923	48.39	34.62	49.07	35.37	48.48	37.55	48.04	38.86	13.43
93	945	48.63	34.84	49.76	34.83	49.45	36.98	49.11	38.30	13.12
94	968	49.19	35.39	50.22	34.27	50.35	36.37	50.05	37.69	12.81
95	992	50.41	35.97	50.32	33.70	51.13	35.76	50.91	37.09	12.50
96	1016	51.91	36.31	49.80	33.69	51.80	35.16	51.61	36.50	12.20
97	1041	53.62	35.62	51.01	36.24	52.25	34.50	52.01	35.88	11.91
98	1067	54.73	34.92	53.03	35.59	52.65	34.36	52.51	35.79	11.62
99	1093	55.68	34.24	54.48	34.96	53.18	34.22	53.11	35.70	11.34
100	1119	56.53	33.60	55.46	34.36	53.78	34.08	53.77	35.62	11.08
101	1147	57.33	32.93	56.40	33.74	54.46	33.94	54.52	35.53	10.81
102	1175	58.06	32.29	57.22	33.14	55.18	33.81	55.28	35.44	10.55
103	1204	58.68	31.66	57.93	32.55	55.92	33.67	56.12	35.35	10.30
104	1233	59.26	31.06	58.53	31.98	56.71	33.53	57.06	35.26	10.06
105	1263	59.73	30.50	59.09	31.47	57.62	33.32	58.12	35.06	9.82
106	1294	60.23	30.06	59.65	31.08	58.47	32.92	59.09	34.59	9.58
107	1326	60.76	29.61	60.23	30.69	59.26	32.52	59.98	34.13	9.35
108	1358	61.28	29.18	60.83	30.31	60.00	32.14	60.79	33.68	9.13
109	1392	61.82	28.74	61.45	29.93	60.74	31.74	61.60	33.22	8.91
110	1426	62.36	28.32	62.09	29.56	61.47	31.36	62.39	32.78	8.69
111	1460	62.92	27.92	62.75	29.20	62.22	31.00	63.18	32.36	8.49
112	1496	63.59	27.44	63.55	28.75	63.09	30.54	64.08	31.84	8.29
113	1533	64.14	26.77	64.22	28.04	63.83	29.84	64.85	31.10	8.09
114	1570	64.62	26.14	64.79	27.37	64.47	29.17	65.52	30.40	7.90
115	1609	65.04	25.50	65.28	26.69	65.05	28.49	66.11	29.69	7.71
116	1648	65.39	24.89	65.69	26.05	65.54	27.85	66.63	29.02	7.52
117	1688	65.72	24.30	66.07	25.42	66.00	27.22	67.13	28.36	7.34
118	1730	66.03	23.70	66.43	24.79	66.44	26.59	67.61	27.70	7.17
119	1772	66.30	23.11	66.74	24.16	66.85	25.95	68.03	27.02	7.00
120	1815	66.52	22.51	67.01	23.54	67.19	25.31	68.41	26.35	6.83
121	1860	66.71	21.92	67.25	22.93	67.50	24.67	68.76	25.68	6.67
122	1905	66.86	21.36	67.41	22.34	67.76	24.06	69.01	25.05	6.51
123	1952	66.97	20.80	67.56	21.76	67.97	23.46	69.26	24.41	6.35
124	2000	67.07	20.26	67.72	21.20	68.20	22.87	69.52	23.80	6.20
	$\frac{E\mu(E)}{f_2}$	185.3		181.3		182.1		176.7		$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	227.0		232.0		231.0		238.0		amu

ATOMIC SCATTERING FACTOR, $f_1 + if_2$

N	E(eV)	Np (93) f_1	Np (93) f_2	Pu (94) f_1	Pu (94) f_2	f_1	f_2	f_1	f_2	λ(A)
0	100	-13.83	23.78	-3.62	20.00					124.0
1	102	-15.00	27.61	-4.33	21.82					121.5
2	104	-16.14	31.95	-4.86	23.77					119.2
3	107	-17.60	39.58	-5.41	26.94					115.9
4	110	-10.38	56.38	-5.56	30.43					112.7
5	112	-2.75	57.24	-5.28	32.96					110.7
6	115	7.74	58.51	-4.49	37.06					107.8
7	118	16.35	58.92	-3.03	41.55					105.1
8	121	23.62	55.29	-0.12	46.45					102.5
9	124	29.24	51.96	4.45	51.01					100.0
10	127	33.71	48.09	10.32	54.22					97.6
11	130	36.99	43.36	17.68	55.37					95.4
12	133	38.83	39.19	23.61	53.26					93.2
13	136	39.63	35.49	28.08	51.28					91.2
14	140	40.10	31.21	33.63	47.51					88.6
15	143	39.91	28.73	36.12	44.00					86.7
16	147	39.72	26.07	38.52	39.82					84.3
17	150	39.58	24.28	39.74	37.02					82.7
18	154	39.27	22.13	40.65	33.66					80.5
19	158	38.83	20.22	41.17	30.67					78.5
20	162	38.37	18.59	41.43	28.02					76.5
21	166	37.89	17.13	41.48	25.65					74.7
22	170	37.39	15.82	41.30	23.54					72.9
23	174	36.87	14.64	40.96	21.64					71.3
24	178	36.31	13.56	40.52	19.94					69.7
25	182	35.75	12.59	40.01	18.65					68.1
26	187	35.02	11.50	39.47	17.19					66.3
27	191	34.43	10.72	39.04	16.13					64.9
28	196	33.65	9.83	38.50	14.92					63.3
29	201	32.83	9.07	37.94	13.83					61.7
30	206	31.94	8.37	37.37	12.85					60.2
31	211	31.01	7.89	36.79	11.95					58.8
32	216	30.18	7.62	36.20	11.14					57.4
33	221	29.41	7.37	35.61	10.40					56.1
34	227	28.48	7.09	34.87	9.56					54.6
35	232	27.65	7.06	34.20	8.90					53.4
36	238	26.88	7.20	33.30	8.19					52.1
37	244	26.21	7.33	32.25	7.56					50.8
38	250	25.61	7.46	31.05	7.47					49.6
39	256	25.07	7.59	30.25	7.56					48.4
40	262	24.54	7.72	29.54	7.64					47.3
41	269	23.91	7.86	28.83	7.74					46.1
42	275	23.32	7.99	28.27	7.82					45.1
43	282	22.69	8.37	27.65	7.92					44.0
44	289	22.12	8.78	27.03	8.02					42.9
45	296	21.62	9.20	26.42	8.26					41.9
46	303	21.17	9.63	25.91	8.49					40.9
47	311	20.66	10.14	25.36	8.77					39.9
48	318	20.27	10.63	24.89	9.01					39.0
49	326	19.87	11.22	24.37	9.28					38.0
50	334	19.47	11.82	23.81	9.56					37.1
51	342	19.10	12.44	23.20	9.83					36.3
52	351	18.76	13.15	22.42	10.31					35.3
53	359	18.48	13.80	21.88	10.91					34.5
54	368	18.24	14.56	21.33	11.61					33.7
55	377	18.04	15.33	20.84	12.34					32.9
56	386	17.84	16.13	20.42	13.09					32.1
57	396	17.65	17.04	20.03	13.96					31.3
58	406	17.58	17.98	19.67	14.86					30.5
59	415	17.50	18.85	19.39	15.70					29.9
60	426	17.55	19.94	19.14	16.76					29.1
61	436	17.63	20.86	18.97	17.77					28.4
62	447	17.72	21.89	18.87	18.91					27.7
63	458	17.88	22.94	18.96	20.08					27.1
64	469	18.08	24.02	19.09	21.00					26.4

N	E(eV)	Np (93) Neptunium f_1	Np (93) Neptunium f_2	Pu (94) Plutonium f_1	Pu (94) Plutonium f_2	f_1	f_2	f_1	f_2	λ(A)
65	480	18.32	25.12	19.17	21.94					25.83
66	492	18.67	26.35	19.25	22.98					25.20
67	504	19.19	27.61	19.36	24.05					24.60
68	516	19.91	28.89	19.50	25.15					24.03
69	529	20.61	29.50	19.69	26.36					23.44
70	542	21.02	30.92	19.93	27.60					22.87
71	555	21.68	32.38	20.17	28.86					22.34
72	569	22.92	33.98	20.44	30.25					21.79
73	583	24.51	34.96	20.70	31.93					21.27
74	597	25.86	35.66	21.33	33.88					20.77
75	612	27.25	36.41	22.40	36.06					20.26
76	627	28.66	37.16	24.02	38.32					19.77
77	642	30.34	37.65	26.52	39.94					19.31
78	658	31.89	37.64	28.98	40.16					18.84
79	674	33.20	37.64	30.89	40.38					18.39
80	690	34.33	37.59	32.54	40.52					17.97
81	707	35.40	37.51	34.21	40.57					17.54
82	725	36.39	37.44	35.76	40.19					17.10
83	742	37.28	37.37	36.88	39.85					16.71
84	760	38.14	37.30	37.74	39.50					16.31
85	779	38.24	36.42	38.21	39.14					15.92
86	798	37.98	37.74	37.21	38.79					15.54
87	818	38.60	39.14	39.35	40.59					15.16
88	838	40.26	40.56	40.45	41.13					14.79
89	858	42.24	41.47	41.60	41.66					14.45
90	879	44.40	41.14	42.85	42.21					14.10
91	901	46.01	40.80	44.36	42.79					13.76
92	923	47.51	40.47	46.20	43.35					13.43
93	945	48.89	39.98	48.22	43.10					13.12
94	968	50.05	39.40	49.75	42.46					12.81
95	992	51.14	38.82	51.12	41.81					12.50
96	1016	52.07	38.23	52.27	41.17					12.20
97	1041	52.75	37.53	53.08	40.41					11.91
98	1067	53.39	37.37	53.85	40.25					11.62
99	1093	54.09	37.21	54.67	40.10					11.34
100	1119	54.87	37.06	55.58	39.95					11.08
101	1147	55.74	36.90	56.58	39.79					10.81
102	1175	56.63	36.75	57.60	39.64					10.55
103	1204	57.59	36.59	58.71	39.48					10.30
104	1233	58.68	36.44	59.96	39.33					10.06
105	1263	59.88	36.12	61.32	38.98					9.82
106	1294	61.00	35.40	62.60	38.17					9.58
107	1326	61.91	34.69	63.65	37.37					9.35
108	1358	62.72	34.02	64.58	36.60					9.13
109	1392	63.46	33.33	65.44	35.82					8.91
110	1426	64.09	32.67	66.20	35.08					8.69
111	1460	64.68	32.04	66.93	34.37					8.49
112	1496	65.22	31.42	67.64	33.63					8.29
113	1533	65.73	30.87	68.27	32.87					8.09
114	1570	66.23	30.34	68.86	32.13					7.90
115	1609	66.75	29.80	69.42	31.40					7.71
116	1648	67.23	29.29	69.92	30.69					7.52
117	1688	67.72	28.78	70.40	30.00					7.34
118	1730	68.23	28.28	70.87	29.31					7.17
119	1772	68.70	27.70	71.29	28.61					7.00
120	1815	69.15	27.11	71.69	27.91					6.83
121	1860	69.56	26.53	72.05	27.22					6.67
122	1905	69.88	25.97	72.33	26.56					6.51
123	1952	70.22	25.41	72.61	25.90					6.35
124	2000	70.57	24.86	72.89	25.26					6.20
	$\frac{E\mu(E)}{f_2}$	177.4		172.4						$\frac{keV\text{-}cm^2}{gram}$
	Atomic Weight	237.0		244.0						amu